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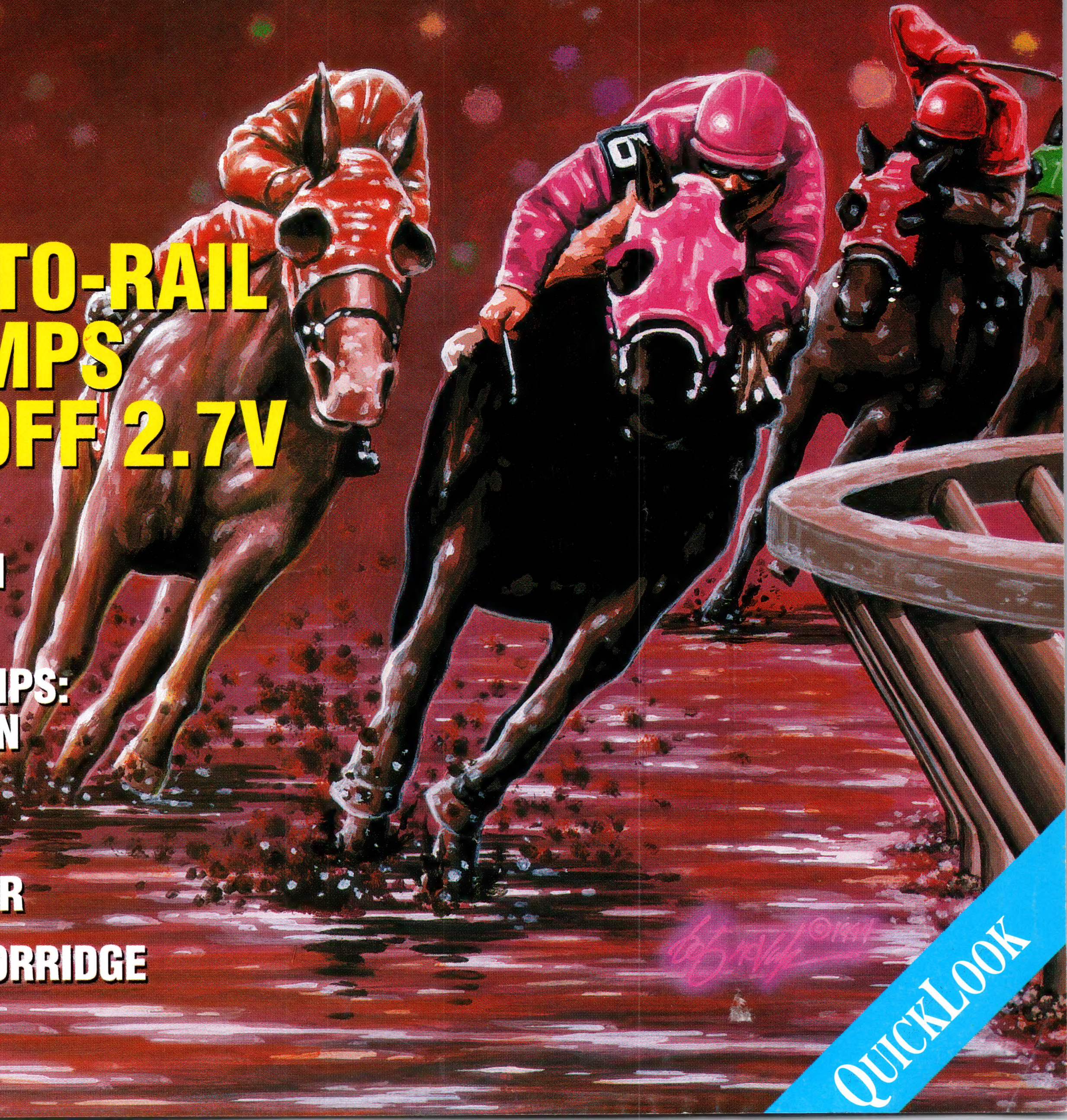
FOR ENGINEERS AND ENGINEERING MANAGERS—WORLDWIDE



AIL-TO-RAIL P AMPS UN OFF 2.7V

FLASH TAKES ON DRAM

DESIGN TIPS: HIGH-GAIN AMPS

PIPS: ON POWER

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QUICKLOOK

V-H-Design; Volker Hilbel, München,

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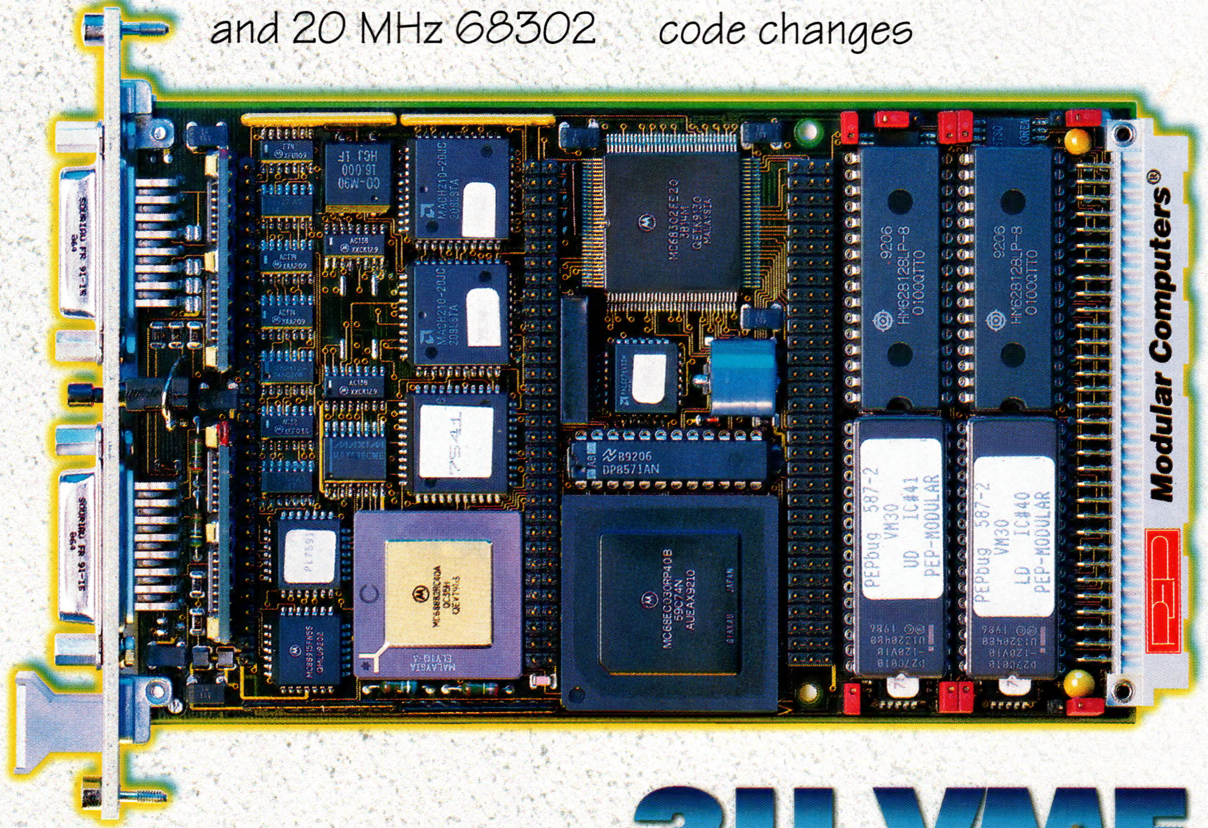
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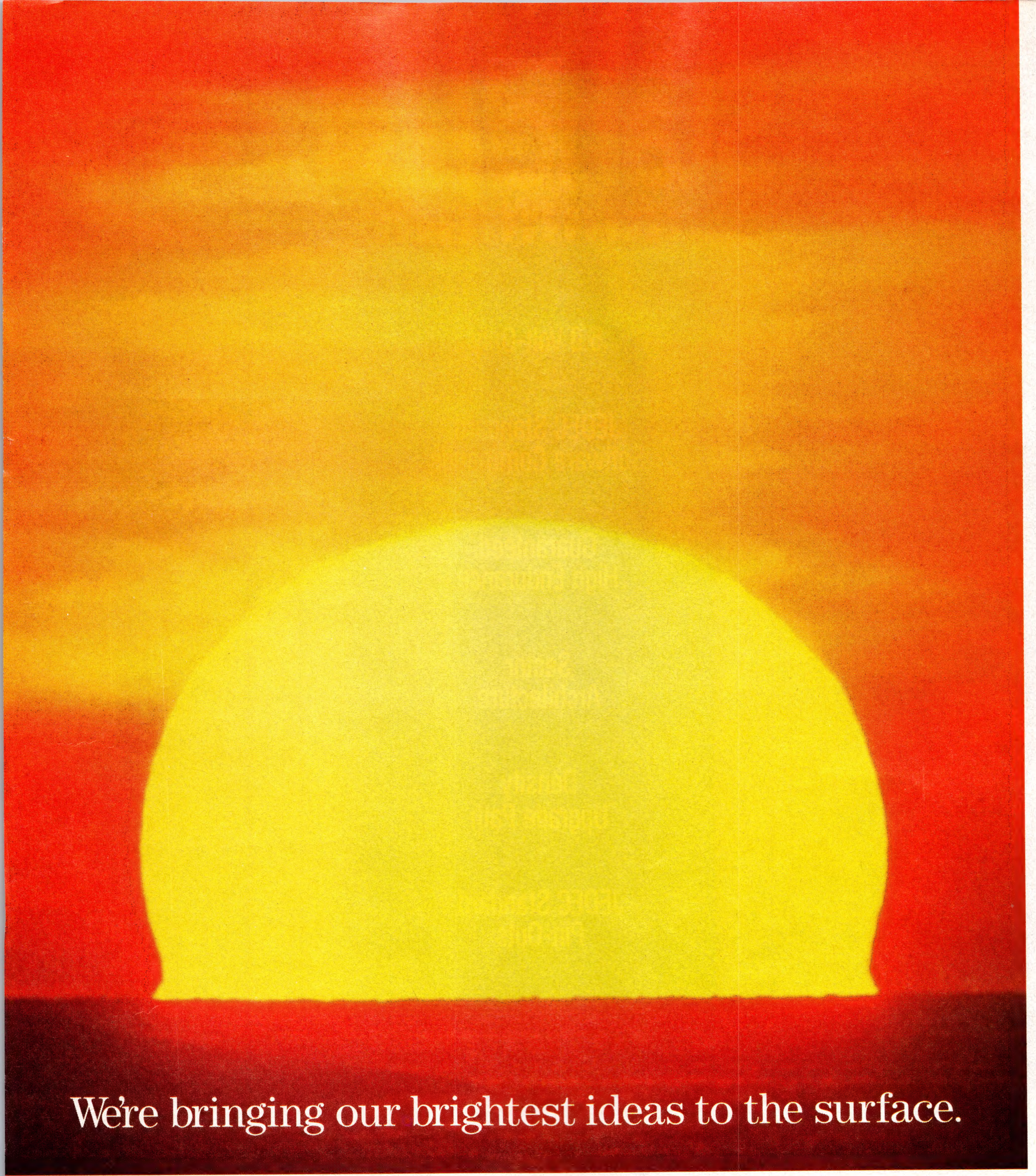

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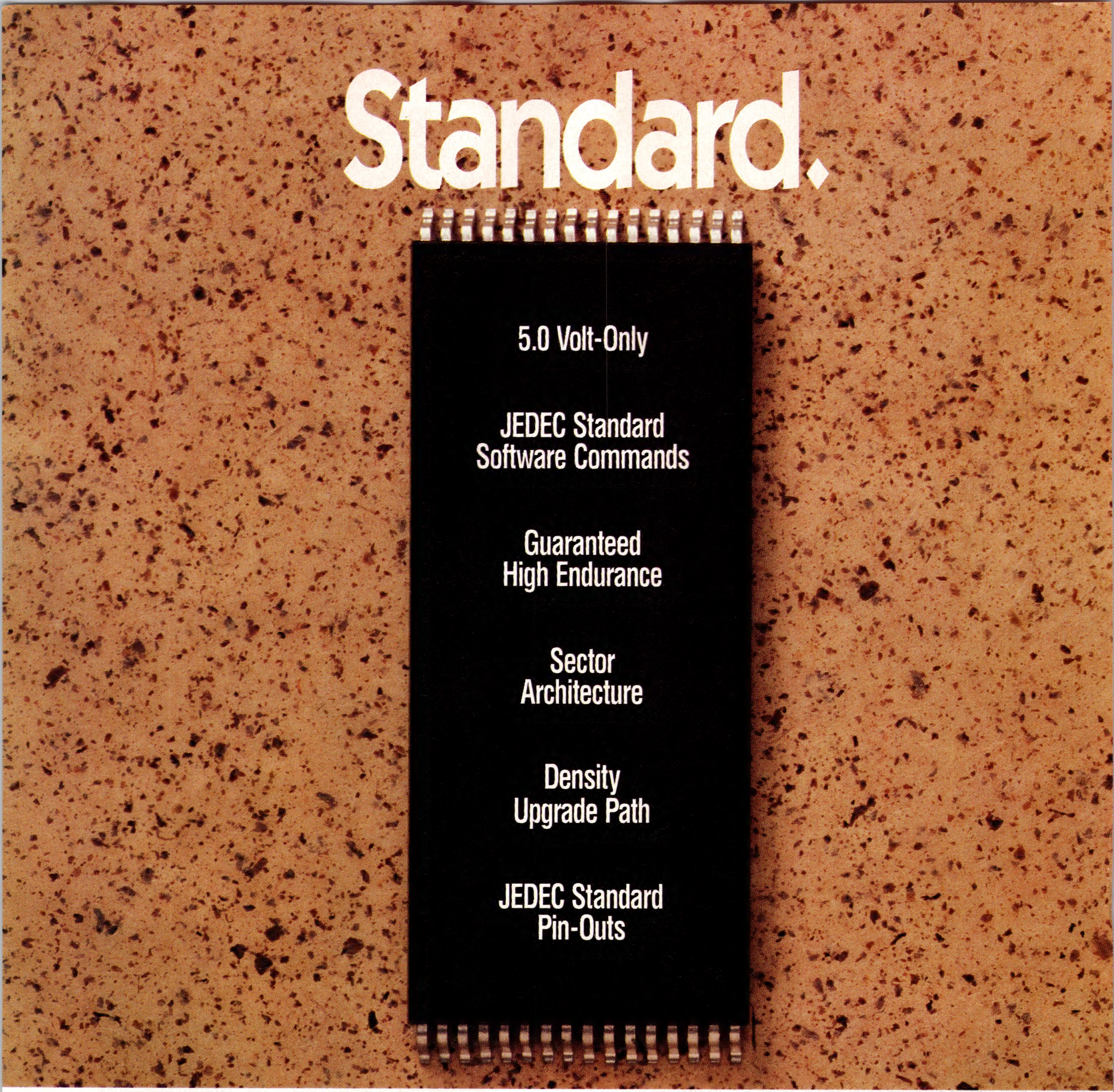

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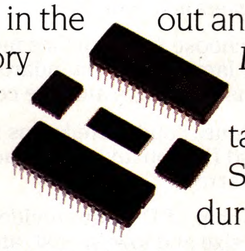
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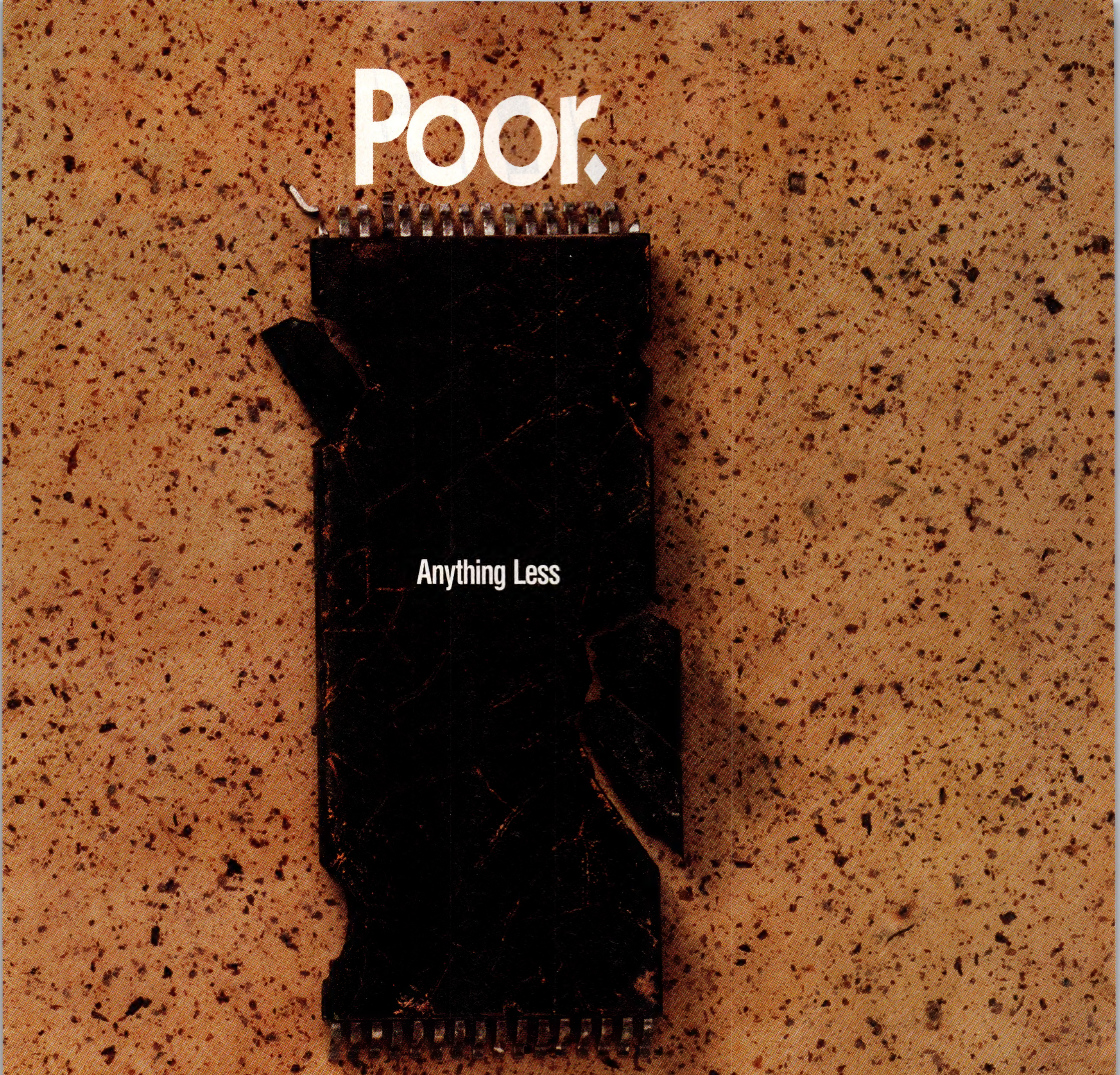

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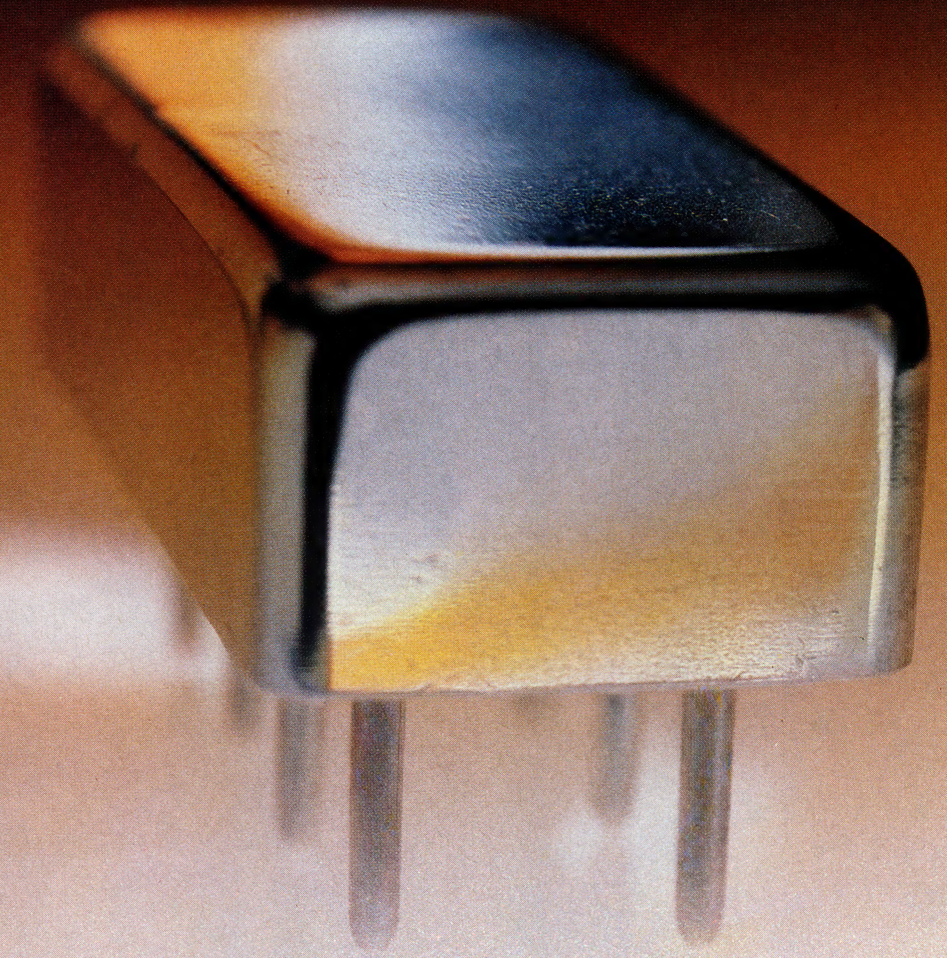

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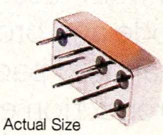

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1968 First Place Award
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1976 Certificate of Merit
1978 Certificate of Merit
1980 Certificate of Merit
1986 First Place Award
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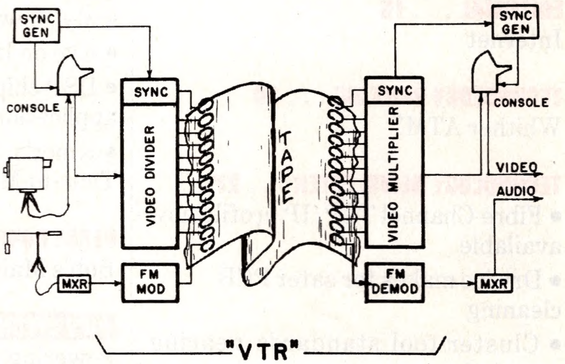
ELECTRONIC DESIGN 40 YEARS AGO

Movies on Magnetic Tape

By extending the top frequency at which magnetic tape recorders can operate, the recording of TV pictures on magnetic tape has been brought close to commercial use. A newly developed Video Tape Recorder can "film" a 20-minute monochrome TV program on ordinary size reels of 3/8" Mylar tape at 100" per second. The tape is divided into 12 channels. The top channel carries the horizontal and vertical synchronization signals. The next 10 channels carry the video signal broken down into bits of information. The last channel carries f-m sound. Ten magnetic recording heads of special design record 339,000 bits per second each on their respective channels for a total of 3,390,000 bits per second. The picture is divided for presentation to the 10 heads by a pulse-forming delay line and electronic switch circuit. On playback, the picture signal is reassembled by a similar circuit.



Developed by the Electronic Division of Bing Crosby Enterprises, Los Angeles, Calif., the Video Tape Recorder has been offered for military use. It may eventually replace photographic methods in the making of motion pictures and kinescopes. It can provide a recording and many simultaneously produced copies, all of which are ready for immediate playback without further processing. Unlike film, the magnetic tape can be erased and reused.

A color recorder based on the same principles as the monochrome unit is now under construction.*(Electronic Design, May 1954, p. 12.)*

Unfortunately, this item leaves many questions unanswered: How is the video signal divided into 10 parts, each represented by a bit stream? How is the signal converted to digital form, and how is it encoded?—SS

Editorial: Help the Reader

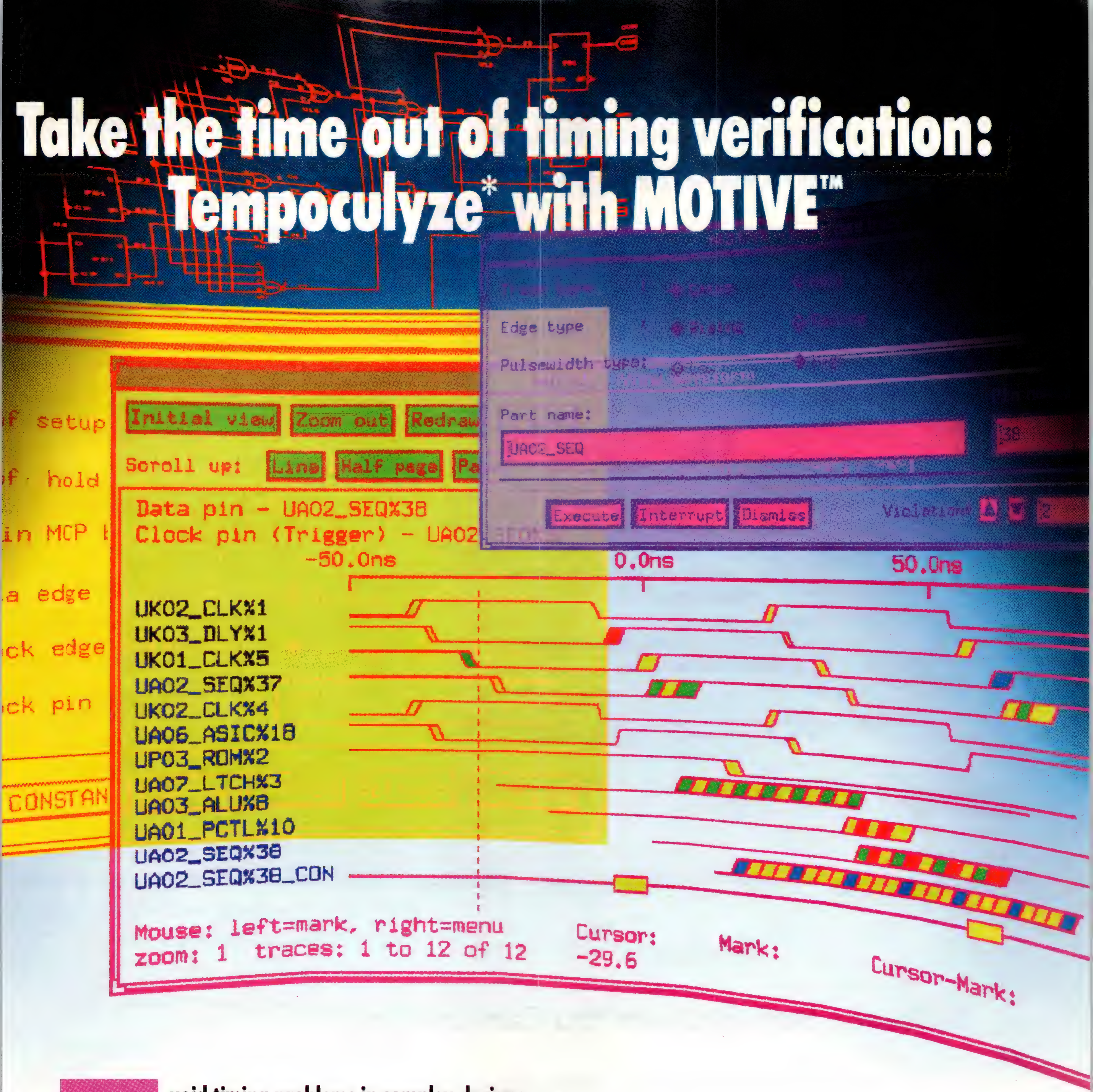
One of the great weaknesses in many engineering articles is their apparent lack of purpose. The author carefully explains how to measure, calculate, or design something, and includes tables, charts, or equations to illustrate his points. Too often, however, he fails to tell the reader why this particular method is important or what are the possibilities of the device he is describing.

The most important part of the article from the reader's point of view is not what is said, but what the information means to him. Why should I take time to read this article? What can I do with this knowledge? How can I adapt it to help solve my problem? Can I go a step further and extrapolate from the author's results?...These are some of the questions in the reader's mind when he looks at an article. It is up to the author to provide the answers clearly and forcefully. Failure to do so can result in losing the reader's interest, because the really interesting implications inherent in many stories are not apparent at first glance_or even after the first casual reading.

In these days of many publications and other demands on a potential reader's time, many articles get only a glance or a quick first reading. If the author has not made the importance of his information apparent, the reader will skip to the next story in the magazine. It takes a lot of hard work to write an article. A little care, thought, and imagination in bringing out the significance of the information being presented will help prevent the author's efforts from being wasted.*(Electronic Design, May 1954, p. 4.)*

This Editorial, written by Edward E. Grazda, Electronic Design's founding Editor, is just as valid today as it was 40 years ago.—SS

Take the time out of timing verification: Tempoculyze* with MOTIVE™



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* ***tempoculyze*** *(tem päk'ye liz') vt.* ***-lyzed, -lyz ing*** *[TEMP (TEMPO)…<L. tempus, time + OCU (OCULAR)…<L. oculus, eye + YZE (ANALYZE)]* ***1.*** *to look into the future of your digital circuit design and know all timing errors before they happen* ***2.*** *to avoid future design mistakes while the design is still a vision* ***3.*** *to exist in the future presently —* ***tem-poc'u-ly-za'tion*** *n.*

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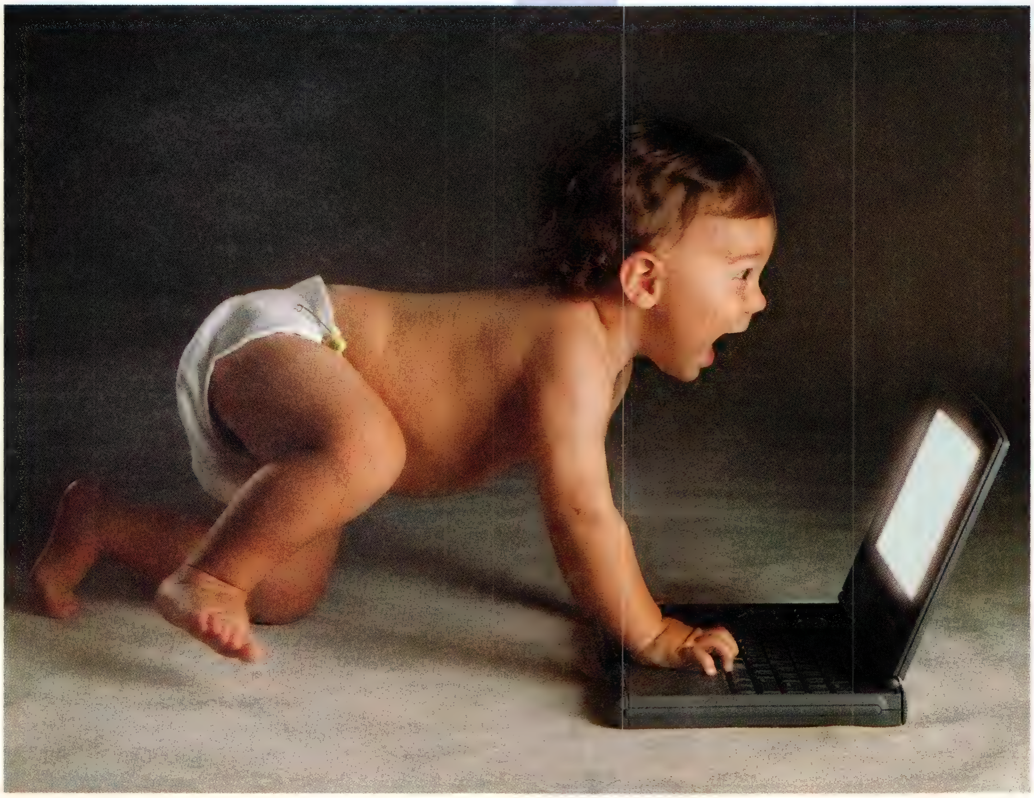

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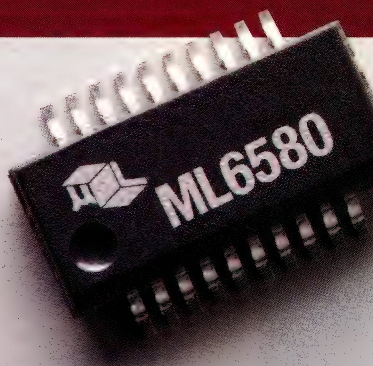

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UPCOMING MEETINGS

MAY

IEEE Microwave & Millimeter-Wave Monolithic Circuits Symposium, May 23-24. San Diego Convention Center, San Diego, CA. Contact Richard B. Gold, Pacific Monolithic Inc., 245 Santa Ana Ct., Sunnyvale, CA 94086; (408) 732-8000, fax (408) 732-3413.

National Aerospace & Electronics Conference (NAECON '94), May 23-27. Dayton Convention Center, Dayton, OH. Contact Sue Murphy, ASC/ENOS, 2664 Skyline Dr., Wright-Patterson Air Force Base, OH 45433-7800; (513) 255-4833, fax (513) 255-8063.

IEEE/MTT-S International Microwave Symposium (MTT '94), May 24-26. San Diego Convention Center, San Diego, CA. Contact Mario Maury, 2900 Inland Empire Blvd., Ontario, CA 91764, (909) 987-4715.

IEEE National Telesystems Conference (NTC '94), May 26-27. San Diego Convention Center, San Diego, CA. Contact Robert R. Bolger, Arinc Research Corp., 4055 Hancock St., San Diego, CA 92110-5152; (619) 222-7447, fax (619) 225-1750.

IEEE International Symposium on Circuits and Systems (ISCAS '94), May 30-June 2. New Connaught Rooms, London, England. Contact Robert Spence, Imperial College of Science, Technology & Medicine; Dept. of Electrical Engineering, Exhibition Rd., London SW7 2BT, England; (44) 71-225-8505, fax (44) 71-581-4419.

6th International Symposium on Power Semiconductor Devices & ICs (ISPSD '94), May 31-June 2. Congress Center Davos, Davos, Switzerland. Contact ISPSD '94, Integrated Systems Laboratory, ETH Zentrum, ETZ, CH-8092 Zurich, Switzerland; phone +41 1 632 42 68; fax +41 1 252 09 94.

JUNE

IEEE 48th Symposium on Frequency Control, June 1-3. Westin Hotel, Boston, MA. Contact Gary R. Johnson, Sawyer Research Products Inc., 35400 Lakeland Blvd., Eastlake, OH 44095; (216) 951-8770, fax (216) 951-1480.

World Congress on Neural Networks, June 4-9. Town and Country Hotel, San Diego, CA. Contact Mary Lou Padgett, Auburn University, 1165 Owens Rd., Auburn, AL 36830; (205) 821-2472, fax (205) 844-1809.

Applied Machine Vision '94, June 6-9. Sheraton Park Place, Minneapolis, MN. Contact Lisa Moody, Society of Manufacturing Engineers, 1 SME Dr., Dearborn, MI 48121-0930; (313) 271-1500, fax (313) 271-2861.

31st Design Automation Conference, June 6-10. San Diego Convention Center, San Diego, CA. Contact M.P. Associates Inc., 5305 Spine Rd., Suite A, Boulder, CO 80301; (303) 530-4333; fax (303) 530-4334.

INFOCOM '94, June 12-16. Westin Harbour Castle, Toronto, Ontario, Canada. Contact Mark J. Karol, AT&T Bell Labs, Room 4F-529, 101 Crawfords Corner Rd., Holmdel, NJ 07733-3030; (908) 949-8590, fax (908) 949-9118, e-mail: mk@boole.att.com.

Society for Information Display, International Symposium Seminar & Exhibition (SID '94), June 12-17. San Jose Convention Center, San Jose, CA. Contact Joyce E. Farrell, SID '94 Conference Chair, Hewlett-Packard Laboratories, P.O. Box 10490, Palo Alto, CA 94303-0969; (415) 857-2807, fax (415) 857-4320, e-mail: Farrell@hplabs.hp.com.

CSI's NetSec '94, Network Security in the Open Environment, June 13-15. Sheraton Palace, San Francisco, CA. Contact CSI Conference Registration, 600 Harrison St., San Francisco, CA 94107; (415) 905-2626, fax (415) 905-2218.

Computer Modeling of Optical Waveguides and Components: A Hands-on Workshop, June 14-17. National Institute of Standards and Technology, Boulder, CO. Contact R.L. Gallawa, U.S. Dept. of Commerce, National Institute of Standards and Technology, 325 Broadway, Boulder, CO 80303-3328; (303) 497-3761, fax (303) 497-3387.

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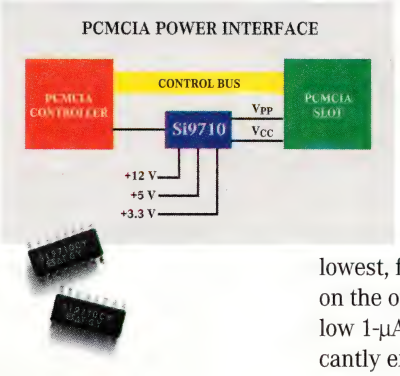

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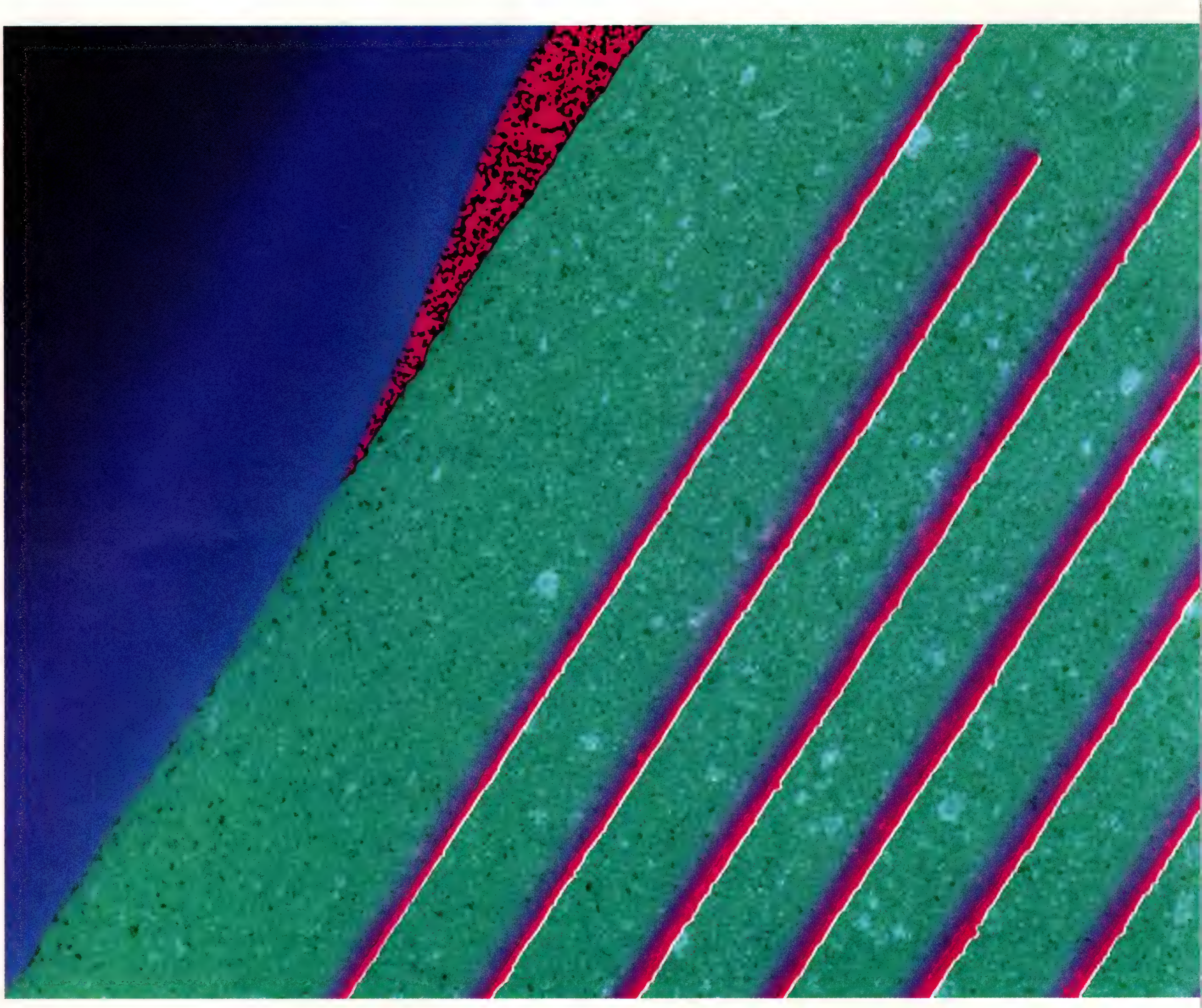

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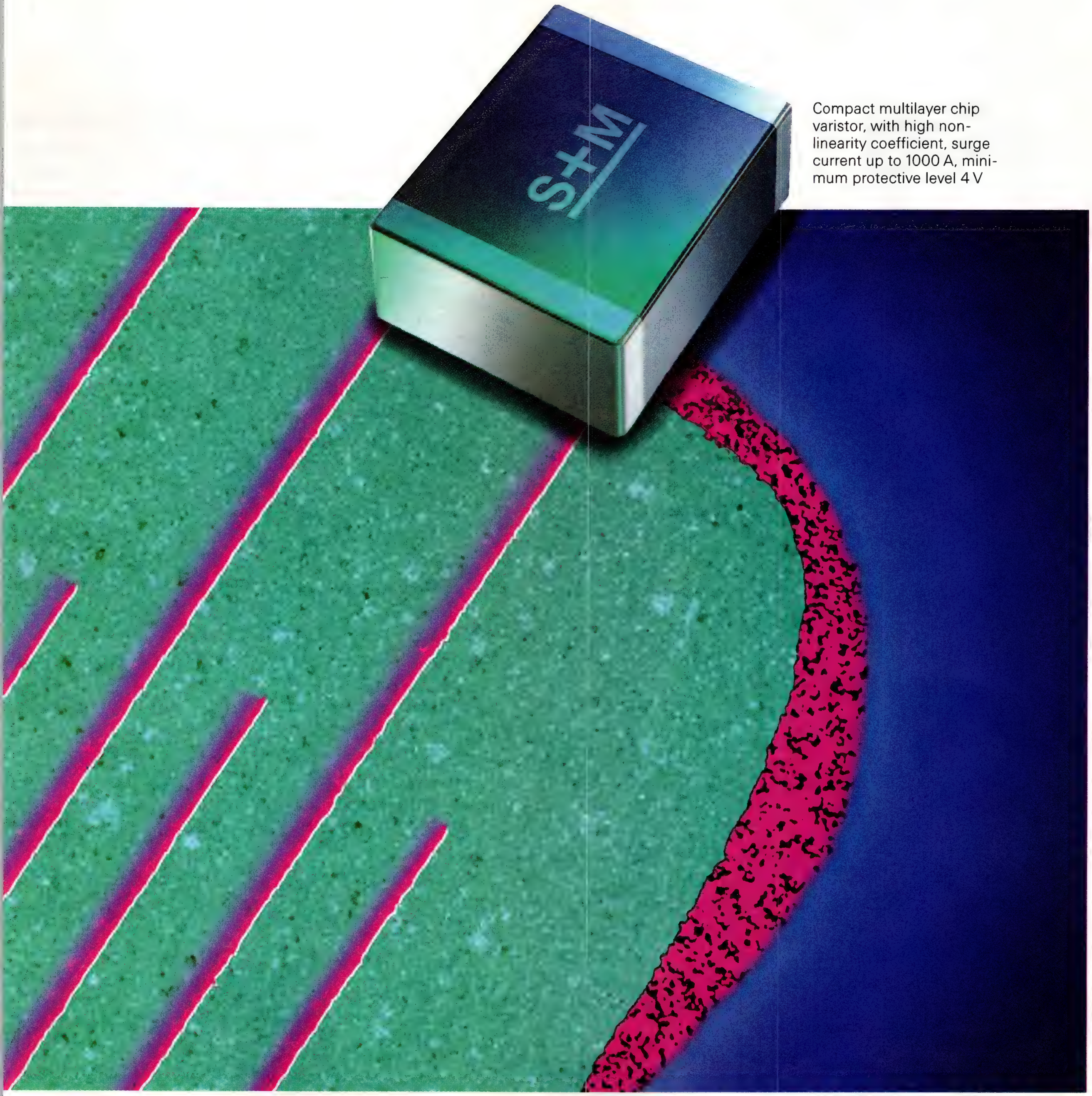

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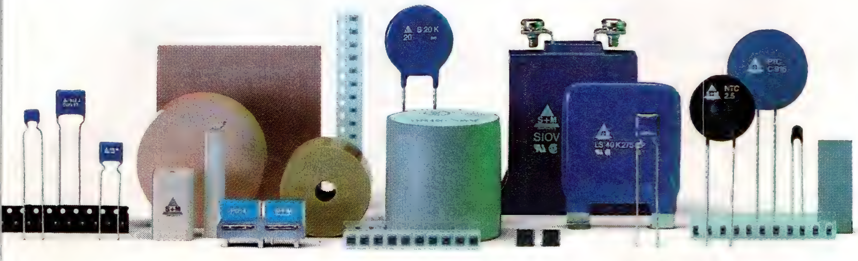

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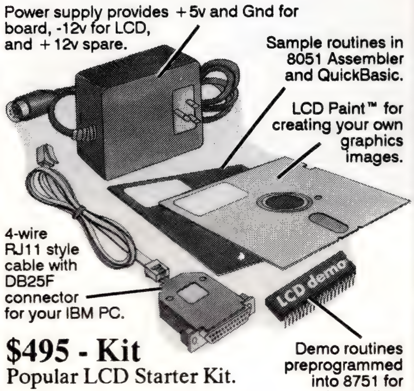
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EDITORIAL

INTERNET

Judging from what I read and view in the popular media, the Information Superhighway is about to construct an off-ramp at my doorstep. If I didn't know better, I would probably also believe that this superhighway's main purpose is to provide with me with a new, improved version of TV. As with any idea that's being hooted about by people who are only slightly knowledgeable about it, the Information Superhighway is undoubtedly suffering from overexposure. Too bad.

A couple of years ago, I attended several news conferences called by the Computer Systems Policy Project, a group comprised of top executives in the computer industry. During those interviews, the CSPP's proposals for an information infrastructure were lucidly explained.

Former Apple Computer Chairman John Sculley was the CSPP's chairman at the time. During the news conferences, I don't recall him envisioning 500 channels of cable TV, or the ability to order movies on demand, or buy diamond rings interactively. In those pre-hype days, the emphasis was clearly on information. The cable-TV and phone companies had not quite caught on yet, so the idea had not been reduced to being a new kind of television.

Instead, CSPP focused on things like using computer and communications technology to cut costs on, say, health care while delivering a better product.

Another key idea was to link "geographically challenged" work groups for concurrent engineering from design conception to manufacturing. More than a few companies are going this route with the Internet. That's good. And I would urge anyone who is experiencing communications problems between distanced work groups to look into an Internet address.

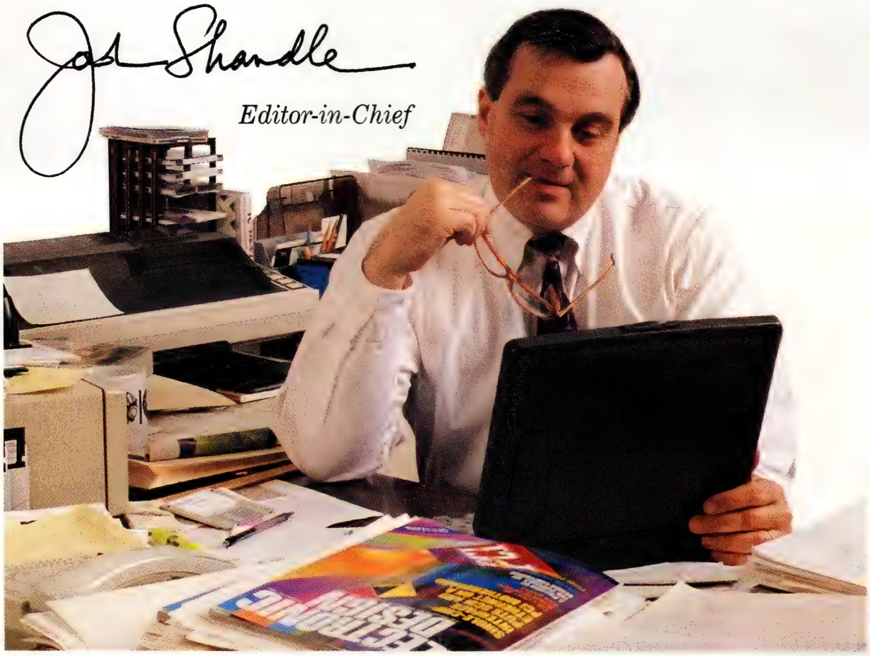
Because the Internet is already there, and not part of a legislative package, this represents a good example of getting back to basics. *Electronic Design* used the Internet with some success to communicate with the engineers presenting papers at the Portable By Design Conference, which we sponsored.

Roughly half our engineer correspondents could be reached by e-mail. We had better communication with them, if for no other reason than the fact that we avoided playing phone tag.

With that experience behind us, we're looking for more practical, commonsense ways to utilize the Internet. One easy example is letters to the editor. Give it a try. Our Internet address is edesign@class.org.

Jon Shandle

Editor-in-Chief



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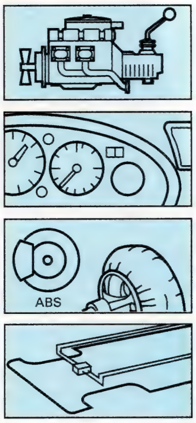

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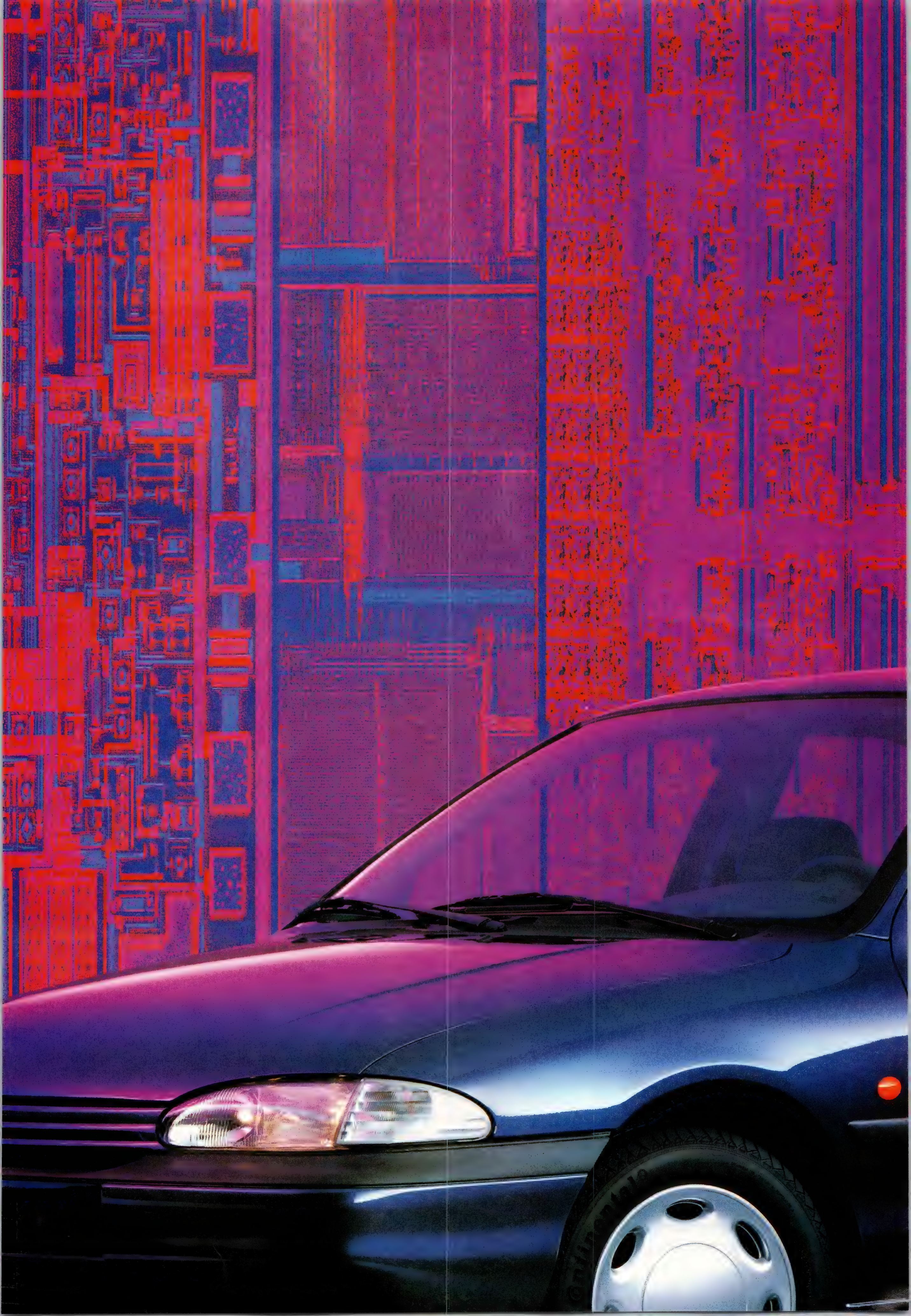


WHITHER ATM?

Over the past weekend, Catherine and I got ready for our annual spring yard sale, a painful but necessary event that keeps us from being buried alive in the trappings of suburban mall culture. Out in the garage, I packed up my old Beta video recorder and quad hi-fi gear, which had been hidden under a pile of old IC data books. As I reluctantly tagged the dusty four-way stereo, I wondered at how it is that such great pieces of electronics end up unloved, unwanted, sitting next to piles of pulp romance novels, old 78-rpm records, and hot-dog electrocuters in somebody's yard sale?

Remember Quad hi-fi? It sounded really great, but was fighting an uphill battle against a large installed base of rather good stereo equipment. Beta recorders, too, offered consumers a better deal with superior performance, more features, and smaller tapes. Unfortunately, an alliance of competitors pulled an end-run around Sony, flooding the market with low-cost VHS units.

What does all this have to do with ATM? Well, the technology promises to be a universal solvent for all data types, providing seamless wideband network interfaces for data, voice, video, and who knows what else. While not perfect, ATM works. In fact, it works rather well. Once the specs for signaling and call setup are ironed out, and attention is paid to congestion management, no serious technical obstacles will stand in the way of adopting ATM as the medium of choice for all new LANs and WANs.

ATM's ability to transport great gobs of any kind of information, with the same ease that we place a phone call, seems to make it a key technology in the ongoing information revolution. Unfortunately, history proves that technical superiority doesn't always guarantee success. What, then, must happen to keep ATM from ending up in the great, cosmic technology yard sale, gathering dust next to fluidic logic, bubble memories, and the PC Junior?

LEE GOLDBERG
COMMUNICATIONS

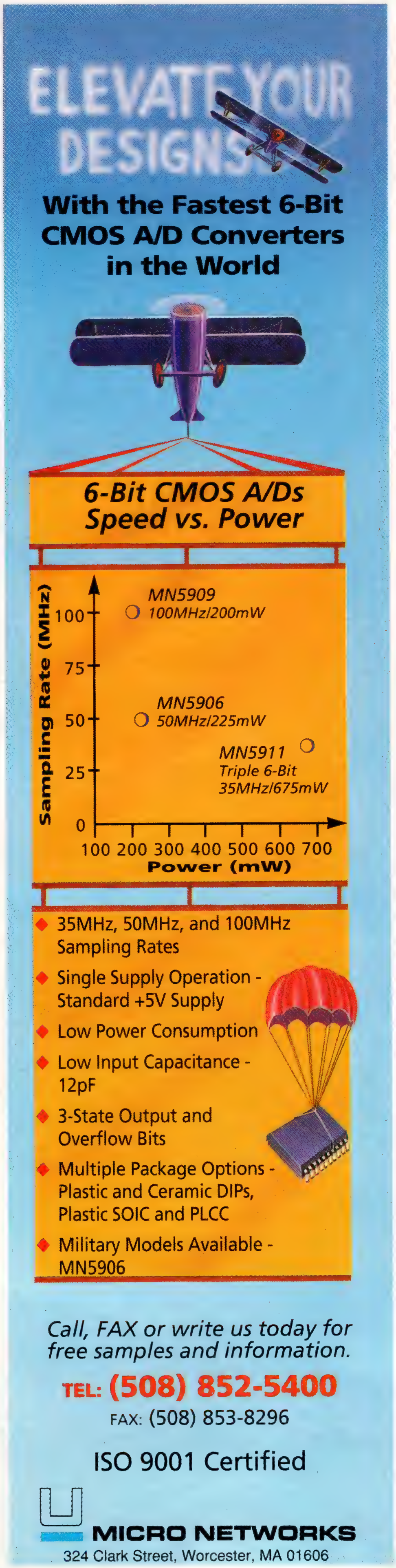
The biggest hurdle ATM may face is the huge installed base of Ethernet, token-ring, FDDI, and other technologies, which work just fine for the moment. Many major LAN equipment suppliers are rushing to fill the high-speed network gap with intermediate technologies, such as 100Base-T, IsoEnet, and 100VG-AnyLan. Many MIS managers will look to these products for a smooth upgrade path to meet evolving needs, rather than take the "forklift" solution. While these are good interim strategies, I'm concerned that they may further fragment the installed base, making unification by ATM more difficult.

Cost is another big consideration. Today, per-node costs of an ATM hookup are at least $1000. Fortunately, price is expected to drop significantly if the next generation of integration produces lower-cost interface and switching solutions. We must remember, however, that the economic viability of these devices rests in high-volume sales.

With luck, ATM's LAN emulation features will help it gain a toe-hold in heterogeneous environments by allowing present client-server applications to run on ATM links with no alteration. ATM's implementation also should be aided by its flexible architecture, which permits it to encapsulate other protocols, such as Ethernet and Frame Relay, for transport between major LAN segments. This will help smooth the migration path that most industry seers predict, in which ATM will find its first major market as a high-speed, internetworking backbone, and then trickle down to the desktop.

It will be a dicey race, but my money is on ATM. The real driver behind any technology is demand. If software packages and services are developed that demand the speed and power offered by ATM, then ATM or its successor will be drafted for service.

In the meantime, I'll load up my DeLorean with the old hi-fi gear and drop it off at the yard sale.



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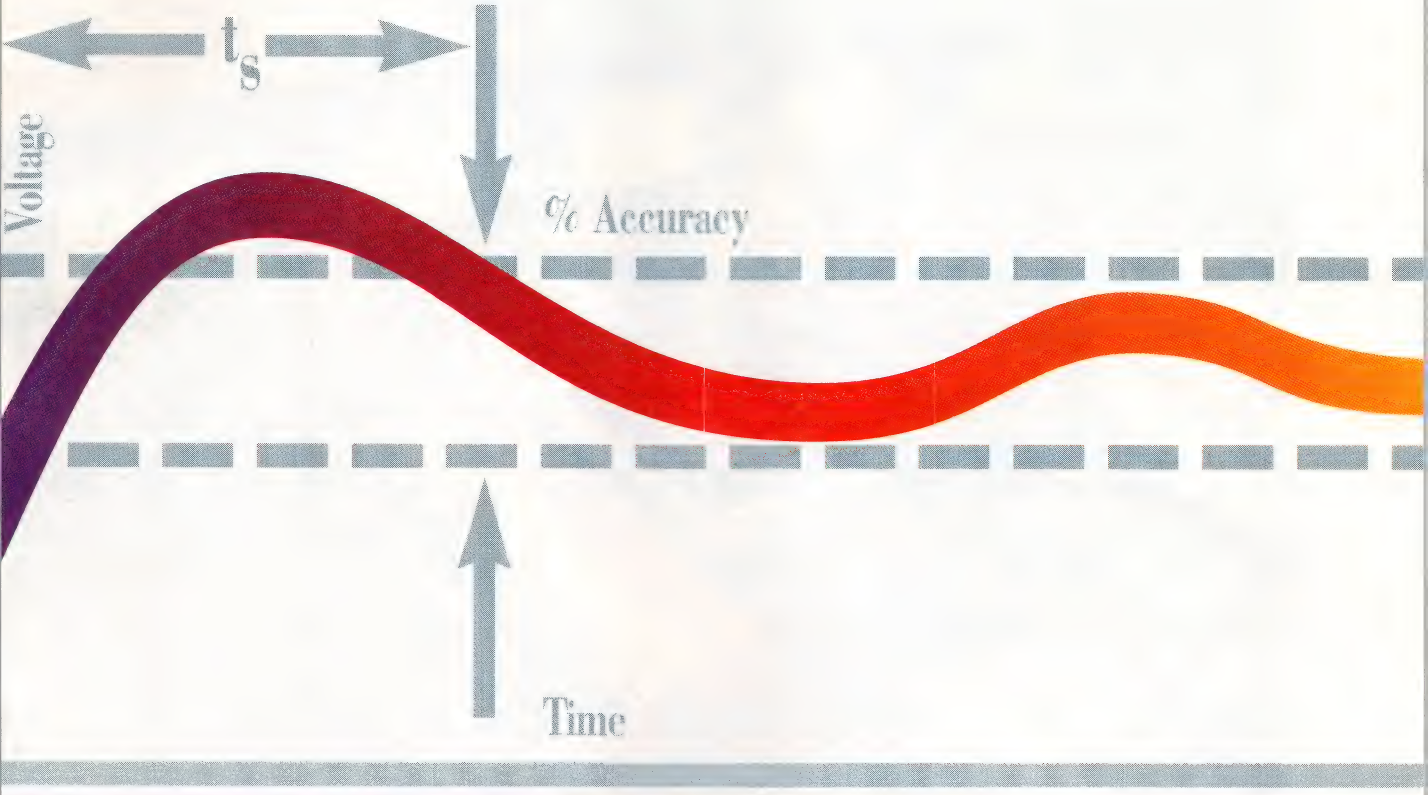

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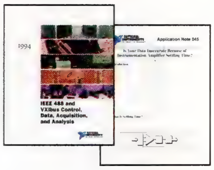

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Design delays taking thei

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	Altera FLEX	Typical Gate Array
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Up Front NRE Cost	No	Yes
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Reprogrammability	Yes	No
In-Circuit Reconfigurability	Yes	No
Flexibility for Design Changes	High	Low
Industry Standard CAE Support (VHDL, Verilog)	Yes	Yes

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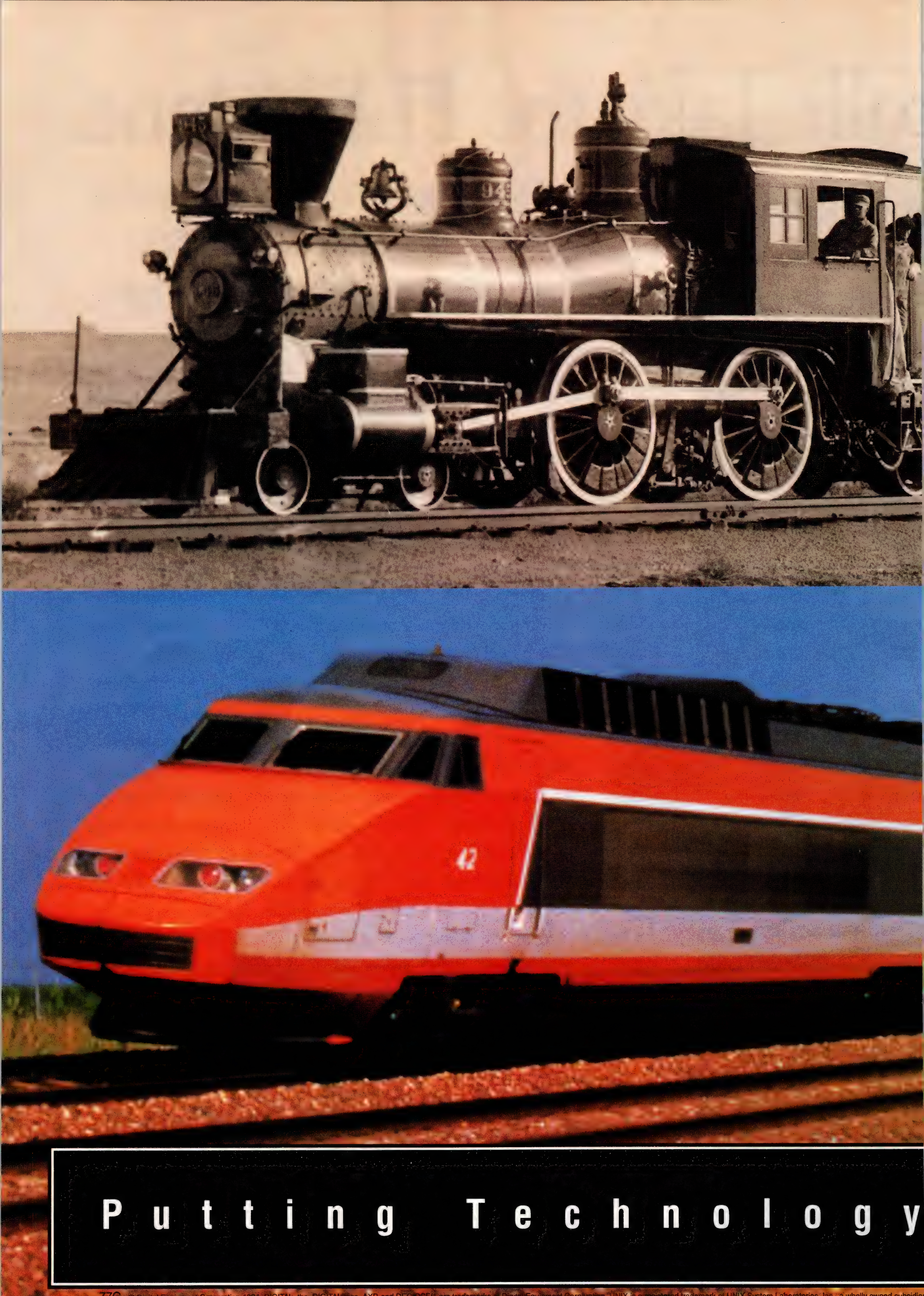

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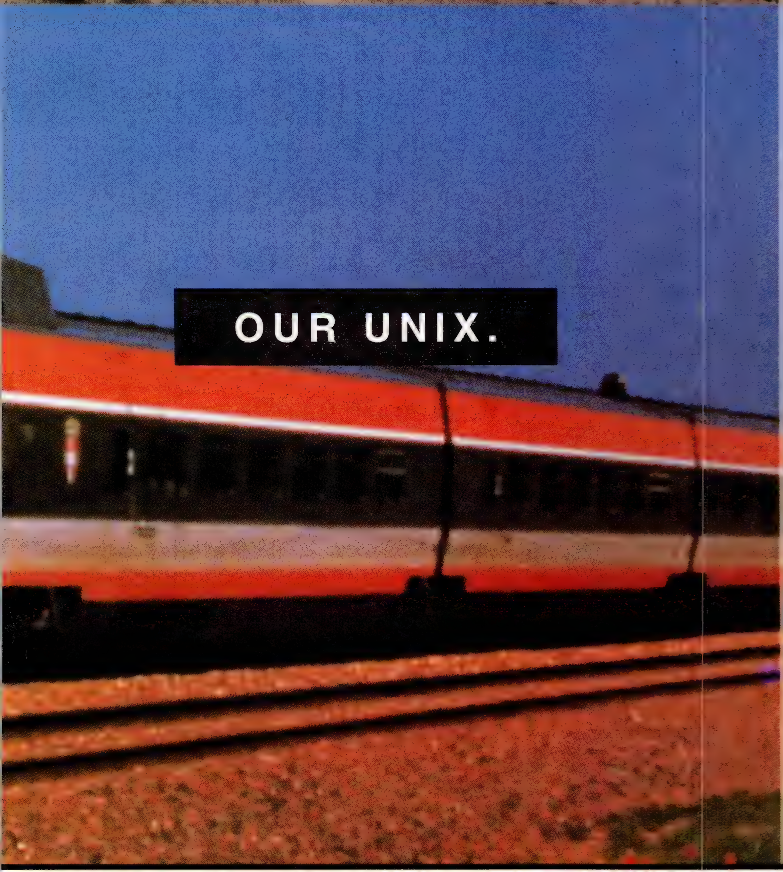

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To make a long story short, two-thirds into the newspaper phase, Celebrity's ships were just about full to the end of the season. With so little left to sell, we all agreed to hold the radio and TV and save the remainder of the budget.

In roughly two years Celebrity became the number one cruise line from New York to Bermuda.

We've just added another new luxury ship and we're anxious to fill it. So once again we've upped our budget. So far, our agency hasn't tried to talk us out of it."

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Sometimes you just gotta stop and smell the saltwater.
If you've never been early for anything in your life, it's probably because nobody made it worth your while.
With prices like these, you'd probably expect to row.
The last time the launching of a ship got this much attention it rained for 40 days and 40 nights.
The only thing standing between you and our cruise to Bermuda is $895 and an occasional pothole.
Once a year the swallows fly to Capistrano. The salmon swim to their spawning ground. And Floridians cruise to Bermuda.
It's like Monty Hall putting the big deal behind all three doors.
Sure, you could crawl in a hole and hide. But wouldn't our bright spacious cabins be more comfortable?

Al Wallack, Sr. VP Marketing, Celebrity Cruises, after returning from having his hearing checked.

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TECHNOLOGY NEWSLETTER

FIBRE CHANNEL TCP/IP PROFILE NOW AVAILABLE

The Transmission Protocol/Internet Protocol (TCP/IP) profile, a recently introduced set of specifications, will ensure interoperability among virtually all Fibre Channel products. It also will provide a simplified guide for developing Fibre Channel products to be used in TCP/IP-based applications. These specifications are the result of efforts by the Fibre Channel Systems Initiative (FCSI), a joint program of Hewlett-Packard Co., IBM, and Sun Microsystems, working closely with the Fibre Channel Association (FCA), which consists of more than 40 members. The specifications come at a crucial time in the development of Fibre Channel technology, drawing special attention to the potential use of Fibre Channel for both workstation clustering and as a network connection. Copies of the Fibre Channel TCP/IP profile may be obtained by mail. Send requests to Gladys Van Polanen Petel, FCSI, Sun Microsystems, Mail Stop MTV 16-04, 2550 Garcia Ave., Mountain View, Calif., 94043-1100. *CA*

DRY ICE MAKES FOR SAFER PCB CLEANING

Long used as a refrigerant, solid carbon dioxide, or dry ice, has been found to be an effective cleaning agent for pc boards. Researchers at AT&T Bell Laboratories, Princeton, N.J., experimented by blasting pressurized pellets of carbon dioxide at the surface, cleaning the board in a way similar to sand blasting. Unlike sand, however, the pellets change directly to a gas after removing the contaminant and don't contribute to the waste generated by the cleaning process. Cost savings can be significant in cases where the contaminant is considered hazardous and requires special treatment and/or disposal. Solid carbon dioxide may prove a suitable replacement for environmentally noxious cleaners traditionally used in electronics manufacturing. Variables such as pellet size and impact speed allow a wide range of cleaning applications, from paint stripping to cleaning delicate test-probe fixtures. Test-probe cleaning is being tried at AT&T's Denver Works, where the carbon-dioxide process is making it easier to troubleshoot bed-of-nails fixtures. For more information, call AT&T's Peter Read at (609) 639-2804. *DM*

CLUSTER-TOOL STANDARDS NEARING COMPLETION

Efforts are underway to release a completed set of international standards for cluster tools by early 1995. Cluster tools, which refer to a semiconductor manufacturing system made up of fully integrated, independent process modules that are mechanically linked together, offer increased semiconductor throughput, enhanced yield, and broadened manufacturing flexibility. This effort, headed by the Semiconductor Equipment and Materials International's Modular Equipment Subcommittee for Communication (SEMI MESC), Mountain View, Calif., will seek to make standards interoperability possible among modules from independent suppliers. As a result, applications software can be developed to support a minimal, but specific set of standard services. The standards will address exception handling and error recovery, as well as deal with the establishment of fundamental requirements for numerous semiconductor manufacturing related processes. The focus of all work on the standards will concentrate only on control areas where equipment companies don't compete. It won't dictate control architecture, or indirectly make tools more expensive, less productive, or less reliable. Effects of these standards for semiconductor manufacturing equipment, like cluster tools, will be widespread, helping to reduce the overall cost of ownership of production systems. The complete set of standards should be available by early 1995. For further information, contact SEMI at (415) 940-6977. *CA*

VACUUM DEPOSITION IMPROVES LITHIUM CELLS

A vacuum-deposition process known as web coating may be the ticket to improved electrodes and electrolytes for lithium polymer batteries. The efficiency of such batteries and their ability to hold a charge depends on the bonding quality between the batteries' various polymer and metal layers. Scientists at Battelle's Pacific Northwest Laboratories, Richland, Wash., have successfully used vacuum deposition to create these layers molecule by molecule. The result is bonding without microscopic voids, contaminants, or trapped gases between layers, problems that often occur using traditional mechanical presses. The larger area of electrical contact achieved using deposition improves the batteries' efficiency. Pacific Northwest Laboratories is now looking for industrial partners with whom to commercialize the technology. For more information, contact Laura Silva at (509) 372-4590. *DM*

FILTERS

dc to 3GHz from $\$11^{45}$

lowpass, highpass, bandpass

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- greater than 40dB stopband rejection
- surface-mount
- BNC, Type N, SMA available
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- VSWR less than 1.7 (typ)
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- meets MIL-STD-202 tests
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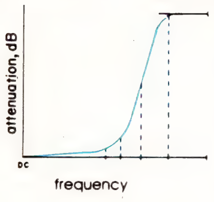
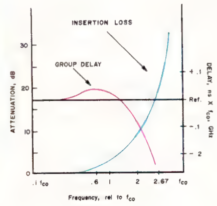
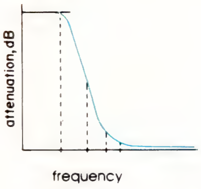
LOW PASS

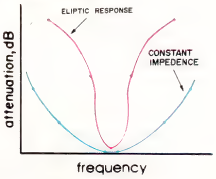




HIGH PASS



BANDPASS



low pass, Plug-in, dc to 1200MHz

Model No.	Passband MHz loss < 1dB	Stopband, MHz loss > 20dB	Stopband, MHz loss > 40dB
★LP-5	DC-5	8-10	10-200
★LP-10.7	DC-11	19-24	24-200
★LP-21.4	DC-22	32-41	41-200
★LP-30	DC-32	47-61	61-200
★LP-50	DC-48	70-90	90-200
★LP-70	DC-60	90-117	117-300
★P-90	DC-81	121-137	167-400
★LP-100	DC-98	146-189	189-400
★LP-150	DC-140	210-300	300-600
★LP-200	DC-190	290-390	390-800
★LP-250	DC-225	320-400	400-1200
★LP-300	DC-270	410-550	550-1200
★LP-450	DC-400	580-750	750-1800
★LP-550	DC-520	750-920	920-2000
★LP-600	DC-680	840-1120	1120-2000
★LP-750	DC-700	1000-1300	1300-2000
★LP-800	DC-720	1080-1400	1400-2000
★LP-850	DC-760	1100-1400	1400-2000
★LP-1000	DC-900	1340-1750	1750-2000
★LP-1200	DC-1000	1620-2100	2100-2500

Price, (1-9 qty), all models: plug-in $14.95, BNC $32.95, SMA $34.95, Type N $35.95

Surface-mount, dc to 570MHz

SCLF-21.4	DC-22	32-41	41-200
SCLF-30	DC-30	47-61	61-200
SCLF-45	DC-45	70-90	90-200
SCLF-135	DC-135	210-300	300-600
SCLF-190	DC-190	290-390	390-800
SCLF-380	DC-380	580-750	750-1800
SCLF-420	DC-420	750-920	920-2000

Price, (1-9 qty), all models: $11.45

Flat Time Delay, dc to 1870MHz

Model No.	Passband MHz loss < 1.2dB	Stopband MHz loss > 10dB	Stopband MHz loss > 20dB	VSWR Freq. Range, DC thru 0.2fco X̄	VSWR Freq. Range, DC thru 0.6fco X̄	Group Delay Variations, ns Freq. Range, DC thru fco X̄	Group Delay Variations, ns Freq. Range, DC thru 2fco X̄	Group Delay Variations, ns Freq. Range, DC thru 2.67fco X̄
★BLP-39	DC-23	78-117	117	1.3:1	2.3:1	0.7	4.0	5.0
★BLP-117	DC-65	234-312	312	1.3:1	2.4:1	0.35	1.4	1.9
★BLP-156	DC-94	312-416	416	0.3:1	1.1:1	0.3	1.1	1.5
★BLP-200	DC-120	400-534	534	1.6:1	1.9:1	0.4	1.3	1.6
★BLP-300	DC-180	600-801	801	1.25:1	2.2:1	0.2	0.6	0.8
★BLP-467	DC-280	934-1246	1246	1.25:1	2.2:1	0.15	0.4	0.55
▲BLP-933	DC-560	1866-2490	2490	1.3:1	2.2:1	0.09	0.2	0.28
▲BLP-1870	DC-850	3740-6000	5000	1.45:1	2.9:1	0.05	0.1	0.15

Price, (1-9 qty), all models: plug-in $19.95, BNC $36.95, SMA $38.95, Type N $39.95
NOTE: ▲: -933 and -1870 only with connectors, at additional $2 above other connector models.

high pass, Plug-in, 27.5 to 2200MHz

Model No.	Stopband MHz loss < 40dB	Stopband MHz loss < 20dB	Passband, MHz loss < 1dB	VSWR Passband Typ.
★HP-25	DC-13	13-19	27.5-200	1.8:1
★HP-50	DC-20	20-26	41-200	1.5:1
★HP-100	DC-40	40-55	90-400	1.8:1
★HP-150	DC-70	70-95	133-600	1.8:1
★HP-175	DC-70	70-105	160-800	1.5:1
★HP-200	DC-90	90-116	185-800	1.6:1
★HP-250	DC-100	100-150	225-1200	1.3:1
★HP-300	DC-145	145-170	290-1200	1.7:1
★HP-400	DC-210	210-290	395-1600	1.7:1
★HP-500	DC-280	280-365	500-1600	1.8:1
★HP-600	DC-350	350-440	600-1600	2.0:1
★HP-700	DC-400	400-520	700-1800	1.6:1
★HP-800	DC-445	445-570	780-2000	2.1:1
★HP-900	DC-520	520-660	910-2100	1.8:1
★HP-1000	DC-550	550-720	1000-2200	1.9:1

Price, (1-9 qty), all models: plug-in $14.95, BNC $36.95, SMA $38.95, Type N $39.95

bandpass, Elliptic Response, 10.7 to 70MHz

Model No.	Center Freq. (MHz)	Passband I.L. 1.5 dB Max. (MHz)	3 dB Bandwidth Typ. (MHz)	Stopbands I.L. > 20dB at MHz	Stopbands I.L. > 35dB at MHz
★BP-10.7	10.7	9.6-11.5	8.9-12.7	7.5 & 15	0.6 & 50-1000
★BP-21.4	21.4	19.2-23.6	17.9-25.3	15.5 & 29	3.0 & 80-1000
★BP-30	30.0	27.0-33.0	25-35	22 & 40	3.2 & 99-1000
★BP-60	60.0	55.0-67.0	49.5-70.5	44 & 79	4.6 & 190-1000
★BP-70	70.0	63.0-77.0	68.0-82.0	51 & 94	6.0 & 193-1000

Price, (1-9 qty), all models: plug-in $18.95,
BNC $40.95, SMA $42.95, Type N $43.95

Constant Impedance, 21.4 to 70MHz

Model No.	Center Freq. MHz	Passband MHz loss < 1dB	Stopband loss > 20dB at MHz	VSWR 1.3:1 Total Band MHz
★IF-21.4	21.4	18-25	1.3 & 150	DC-220
★IF-30	30	25-35	1.9 & 210	DC-330
★IF-40	42	35-49	2.6 & 300	DC-400
★IF-50	50	41-58	3.1 & 350	DC-440
★IF-60	60	50-70	3.8 & 400	DC-500
★IF-70	70	58-82	4.4 & 490	DC-550

Price, (1-9 qty), all models: plug-in $14.95,
BNC $36.95, SMA $38.95, Type N $39.95

NOTE: ★**Add Prefix P, B, N, or S for Pin, BNC, N, or SMA connector requirement.**

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GAS APPLICATIONS TO IMPROVE IC PROCESSING

Attempts to develop new gas applications and related gas equipment for use in ultraclean semiconductor processing is the prime focus of a recently extended R&D project. The project, ongoing since 1992, is part of an industrial affiliation program at the Interuniversity Microelectronics Center (IMEC), Leuven, Belgium, in collaboration with The BOC Group, which includes Airco Gases, Murray Hill, N.J. Continuing studies will include specialized work in the areas of dry wafer cleaning and in-situ gas purity analysis with atmospheric-pressure-ionization mass spectrometry (APIMS). In addition, they will generate experimental data for Total Cost of Ownership (TCO) models, designed to assess the value of specific gas-processing improvements through predicted chip-fabrication yields. To obtain further information, contact Martha L. Eckert of Airco Gases at (908) 771-1882. *CA*

INTERLEAVING TECHNIQUE CUTS VRAM REQUIREMENT

By employing a three-way interleaving scheme in video RAM (VRAM), less memory is needed than with current techniques. The three-way scheme—asymmetrical column interleaving—was developed by engineers at Media Vision, Fremont, Calif. Using this technique, a display with a resolution of 1024 by 768 pixels requires just three 2-Mbit VRAMs. Alternative architectures need four similar memory chips. In a 24-bit/pixel true-color system, only 9 instead of 12 VRAM chips are needed. When the value of a pixel is calculated in the traditional method, the information is stored in memory according to a simple symmetrical pattern. Using asymmetrical column interleaving, each pixel on the display has X and Y coordinates that are mapped into the VRAMs' rows and columns. The input to the asymmetrical-column-interleaving circuit is a conventional 20-bit address with 10 Y bits and 10 X bits. The method can be applied to any video subsystem where the display's X dimension isn't an exact multiple of the memory subsystem's interleave factor. For example, 1024 horizontal pixels (in a 1024-by-768-pixel display) fits the model because 1024 can't be evenly divided by 3. For more information, call Media Vision at (800) 845-5870 or (510) 770-8600. *RN*

OPEN SET-TOP GROUP TO DEVISE STANDARDS

The growing interest in digital interactive set-top boxes has prompted the Video Electronics Standards Association (VESA) to form a special interest group, the VESA Open Set Top (VOST) group. A set-top box combines the functionality of current cable-TV boxes with numerous other services, such as e-mail, home shopping, interactivity, and on-demand entertainment and movies. The group will set standards for features and interconnection of hardware subsystems, including video and graphics displays, audio playback, decompression, and network interfaces. The standards developed by the VOST group will lend themselves to consumer TV applications and will be able to handle different networks and operating systems. In addition, the standards will support an open architecture so that component and box manufacturers can implement new technologies and features. The group plans to establish a set of standards by early 1995. Participating companies include Apple, AT&T, Brooktree, Cirrus Logic, General Instruments, Hewlett-Packard, Kaleida, MainStream Control, Microsoft, Motorola, National Semiconductor, Novell, and Viacom. For more information, contact Jill Nakashima of VESA at (408) 435-0333, or call Frank Schwartz, VOST Chairman, at (415) 321-1860. *RN*

WIRELESS-COMMUNICATION STANDARD IS UNDER STUDY

Wireless communications continues to grow at a staggering pace, with more and more players introducing new products and services. Unfortunately, most competitors use proprietary interfaces that force operators to utilize equipment from a single supplier, reducing their choices and locking them into higher equipment and service prices. To eliminate this problem, the Motorola Cellular Infrastructure Group, Pan American Market Div., Arlington Heights, Ill., proposed the adoption of a wireless network standard—the A+ Interface. This standard specifies how a wireless system can manage digital and analog traffic between any manufacturer's cell site and switching equipment. It's based on the European GSM A interface and defines the essential messaging between the Mobile Telephone Switching Office (MTSO) and the RF subsystem for both cellular and personal-communication services (PCS) applications. The standard supports air interfaces for AMPS (IS-553), NAMPS (IS-88), US Digital Cellular (IS-54), and CDMA (IS-95) standards. Furthermore, there's support for network functionality, such as Intersystem Operations (IS-41), as well as two or more air interfaces simultaneously from a single MTSO. The standard has been submitted to the Telecommunications Industry Association and is under review. For further information, contact Motorola at (800) 291-4685. *CA*

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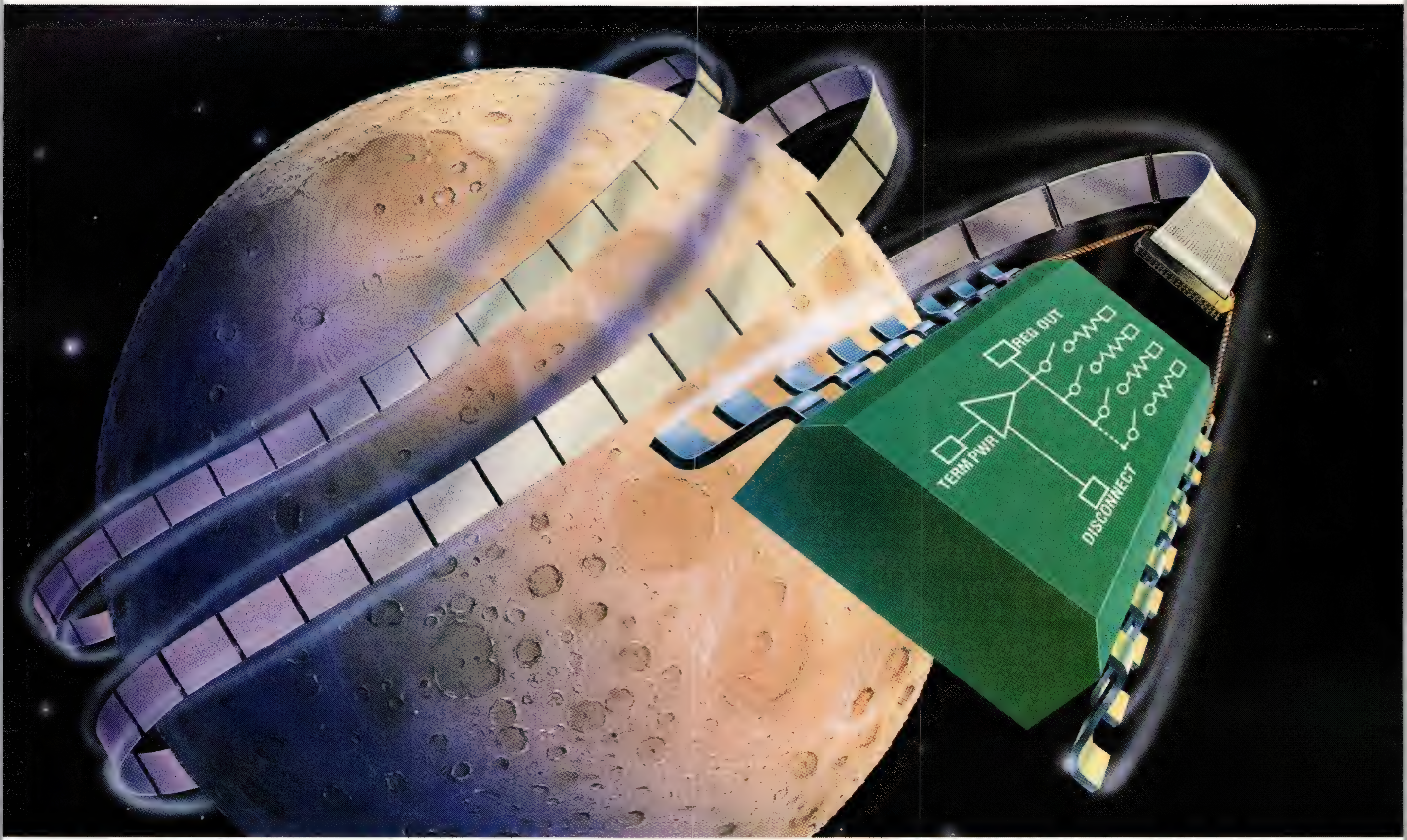

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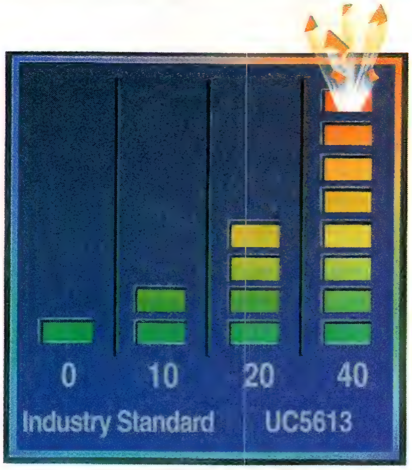

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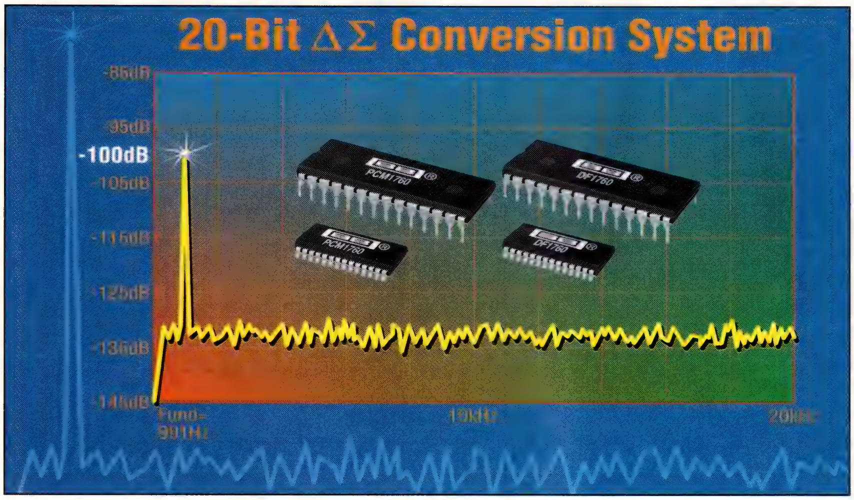

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PCM1760 stereo delta-sigma modulator, together with its matched DF1760 digital filter, provide professional digital audio designers the best combination of analog-to-digital converter performance available for under $30! The system offers 20-bit resolution, wide 108dB dynamic range, very low –92dB THD+N, and clear 110dB SNR. PCM1760 and DF1760 are available in 28-pin DIP and SOIC. PCM1760 operates from ±5V supplies, DF1760 from a single 5V supply.

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The Data Conversion Products IC Data Book contains complete product descriptions, specifications, applications tips, and ordering information for a broad line of high performance, high quality data conversion products. With over 950 pages, it offers more than 25 new high performance data conversion solutions. N products profiled include: A/D and D/A converters acquisition components, sample/hold amplifiers converters, multiplexers, and demonstration boards. The Conversion Products Data Book is **FREE** from any Burr-I sales office or representative.

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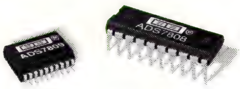

12- and 16-Bit Serial Out, 100kHz Sampling A/Ds

ADS7808 and ADS7809 are low cost, general purpose, serial output, CMOS sampling A/Ds. Both deliver 100kHz sampling rates with very low 100mW power dissipation using a single +5V supply. Ideal for many low power, portable applications requiring high sampling rates with superior accuracy and spectral purity, they're perfect for spectrum analyzers, portable oscilloscopes and vibration analyzers, medical electronics, and process control applications—where their serial output simplifies needed isolation. Available in 20-pin 0.3" plastic DIPs and SOICs.

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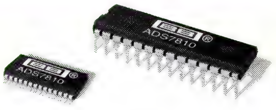

New 12-Bit, Low Power, 800kHz Sampling A/D

ADS7810's 800kHz sampling rate makes it the world's fastest, 12-bit, monolithic SAR ever—60% faster than its closest competitor! Its high speed, small size, low power, low cost, and excellent Nyquist performance make it ideal for data acquisition, DSP boards, and image processing/scanning applications. Key specs include: 800kHz min sampling rate, 12 bits resolution, 70dB min SINAD with 250kHz input, ±0.5LSB max INL, ±0.9LSB max DNL, and 250mW max power dissipation. Available in 28-pin 0.3" plastic DIP, SOIC and die.

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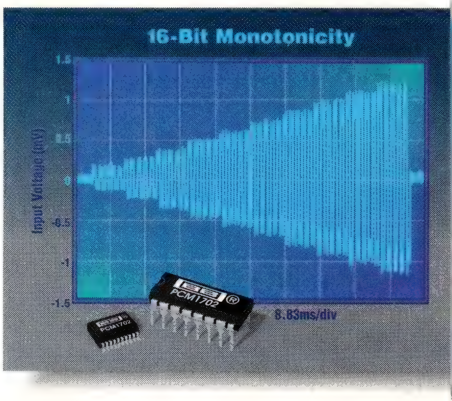

20-Bit BiCMOS DAC

PCM1702's unique architecture produces a 20-bit DAC high dynamic range, high SNR, and very low distor Processed using BiCMOS technology, it has very low p consumption and is packaged in a compact 16-pin plasti or 20-pin SOP. PCM1702 is an unbeatable choice for hig CD players, musical instrumentation and professional applications. Key specs include: –96dB max THD+N, 1 typ dynamic range, 110dB typ SNR, 200ns typ settling and 150mW typ power dissipation.

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+5V Voltage Reference Guarantees Long-Term Stability

REF05 is a precision +5V voltage reference that's a pin for pin replacement for the industry standard REF-05. Its guaranteed long-term output voltage drift of 25ppn hours max is 4 times more stable over extended use than the closest competitor. Key specs are: +5V ±0.1% max output voltage, 8.5ppm/°C max temperature stability, 1 (0.1Hz to 10Hz) noise, 0.008% max line regulation, 0.005%/mA max load regulation, 1.4mA max quiescent current, and 8VDC to 40VDC supply range. Available in an hermetic TO-99.

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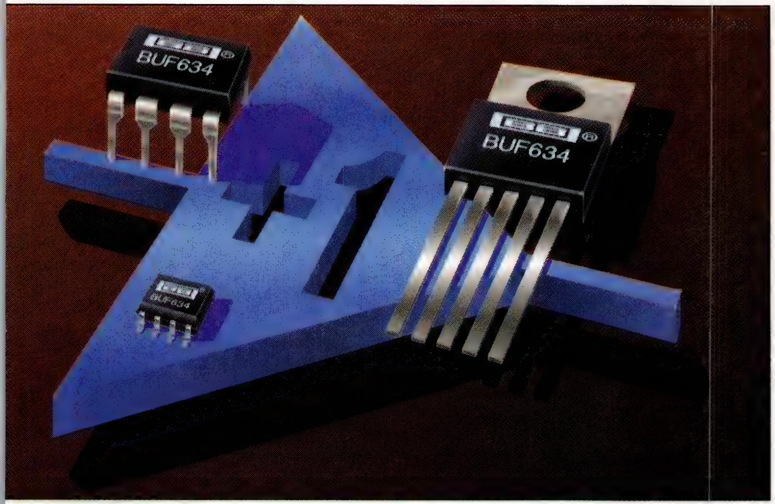
New Product Update



/ 250mA Buffer Amp Slews at 2000V/μs

4 is a high speed, unity-gain buffer amplifier that delivers 250mA output and 2000V/μs slew all in a tiny SO-8 package. Its low price, high performance, rugged monolithic design, and ease make BUF634 ideal for a wide range of general purpose applications. It's an excellent driver for solenoids, video, and even headphones. BUF634 comes in three different packages: an SO-8 e mount, an 8-pin plastic DIP, and a 5-pin TO-220.

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New Linear Products IC Data Book

The Linear Products IC Data Book contains complete product descriptions, specifications, applications tips, and ordering information for a broad line of high performance, high quality linear products. Its 1100+ pages give designers more than 30 new high performance linear ICs. New products profiled include: operational amplifiers, instrumentation amplifiers, isolation products, power operational amplifiers, references, regulators, and demonstration boards. The Linear Products Data Book is **FREE** from any Burr-Brown sales office or representative.

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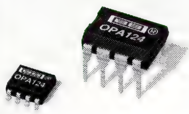

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4 is a precision, monolithic FET op amp elivers low bias current, noise, voltage and drift plus high open loop gain mmon mode rejection. Its versatility, size, and low price make it ideal for cal and laboratory instrumentation, data tion, test/medical equipment, and opto-onics. Key specs include: 6nV/$\sqrt{Hz}$) voltage noise, 1pA max bias current, max drift, 120dB min open loop gain, min common mode rejection, and max offset. Available in compact 8-pin e mount and plastic DIP packages.

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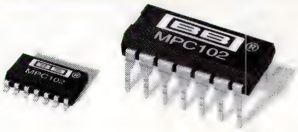

2 x 1 Dual, Video Multiplexer

MPC102 is a dual, 2 x 1 signal multiplexer that distributes and routes wideband analog and digital signals at a high data rate. Designed for high-definition television and broadcast equipment, its excellent harmonic and dynamic specifications are also ideal for radar, communications, computer graphics, and data acquisition systems applications. Key specs include: 210MHz (1.4Vp-p) bandwidth, 640V/μs (2Vp-p) slew rate, 68dB channel crosstalk (30MHz), +6mV/–8mV switching transients, and ±4.6mA (one channel)/±230μA (no channel) quiescent current. Operating from a ±5V supply, MPC102 is available in 14-pin DIPs, SOICs, and dice.

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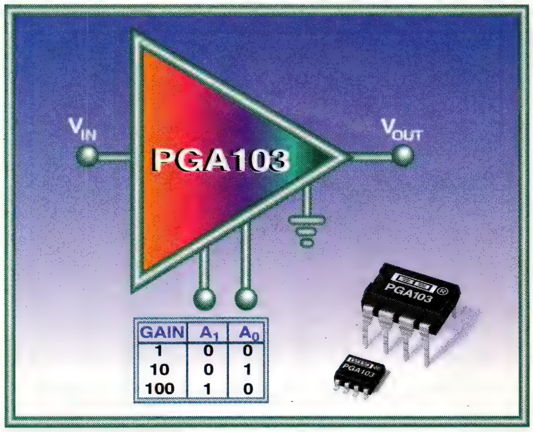

New "Easy-to-Use" Programmable-Gain Amplifier

PGA103 is a monolithic digitally programmable amplifier available in an 8-pin plastic DIP and SO-8 surface mount packages. Gains of 1, 10, and 100 are digitally selected by two TTL- or CMOS-compatible control lines. It's an "easy-to-use" simple solution for systems that handle wide dynamic range signals. PGA103's precision, versatility, size, and low cost make it ideal for process control, medical instrumentation, test/measurement equipment, and general-purpose analog boards. Dice also available.

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) is an ultra high-speed capacitively coupled digital device that provides high isolation with very low power consumption. Designed to replace optocouplers, its low power, high and low cost make it a reliable alternative. Use it for A/D and D/A conversion, multiplexed data transmission, computer-to-peripheral interfaces, I/O port isolation in instruments, inversion, and isolated data acquisition systems. Key specs are: 80M Baud typ data rate, TTL/CMOS compatibility, 25mW max power consumption per channel, tested at rms isolated partial discharge per VDE0884, and 16.5mm creepage distance. Available in 24-pin single-wide plastic DIP.

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FUSE TECHNOLOGY OFFERS HIGH-DENSITY, RADIATION-HARDENED OPTION FOR PALS

Programmable-array-logic (PAL) devices, ICs that surpass EEPROM devices in density, reliability, and radiation hardness, can now be produced thanks to a novel antifuse process. In fact, a PAL layout using the antifuse process takes up roughly one-half the area of a PAL employing a conventional horizontal fuse-link technique. The "fuse" process that produces these PALs is based on a planar amorphous-silicon antifuse which provides a low-impedance electrical connection between two metal layers .

Various technical industries, including the aerospace sector, have long been dominated by the currently available crop of EEPROMs. These devices typically operate at speeds of 150 to 200 ns and are characterized by a total radiation dose of no more than 10,000 rads. Unfortunately, they're plagued by problems of single-event upset. And their low tolerance for radiation makes them virtually unusable in a number of aerospace applications. Moreover, other EEPROM options, such as fuse links, offer no better solutions and occupy too much space.

To address these issues, the United Technologies Microelectronics Center Inc., (UTMC), Colorado Springs, Colo., developed a fuse technology that can support high-density programmable products. This method focuses on a vertically-linked, as opposed to horizontally-linked (for example, a fuse-link), structure as the basis of the fuse design. This effectively allows for higher-density programmable products that are smaller and more cost-effective than those currently available.

The advantages offered by this technology focus not only on reliability, but also on capability. Because the fuse structure is programmed using very low voltage levels, local area stress and heating are avoided, resulting in a more reliable product. In addition, the fuse technology allows products to perform in radiation environments equivalent to 1×10^6 rads.

The design of the vertical antifuse is relatively simple. Basically, it's a one-time programmable-switch between two conductors *(see the figure)*. It consists of a layer of amorphous silicon sandwiched between two layers of titanium tungsten (TiW). This structure is then sandwiched between two metal layers of aluminum-silicon-copper.

In this design, the two TiW layers act as a barrier material between the amorphous silicon (the fuse) and metal layers (the interconnect). Prior to programming, the switch is open and the fuse acts as a dielectric with a high resistance, electrically isolating the conductors (metal layers). A low voltage is then applied between the metal layers to program the antifuse. The resulting power dissipation causes a thermal process that creates a low-resistance path within the fuse. Once programmed, the switch closes, electrically connecting the conductors. The post-program resistance is proportional to the power dissipated in the fuse during programming.

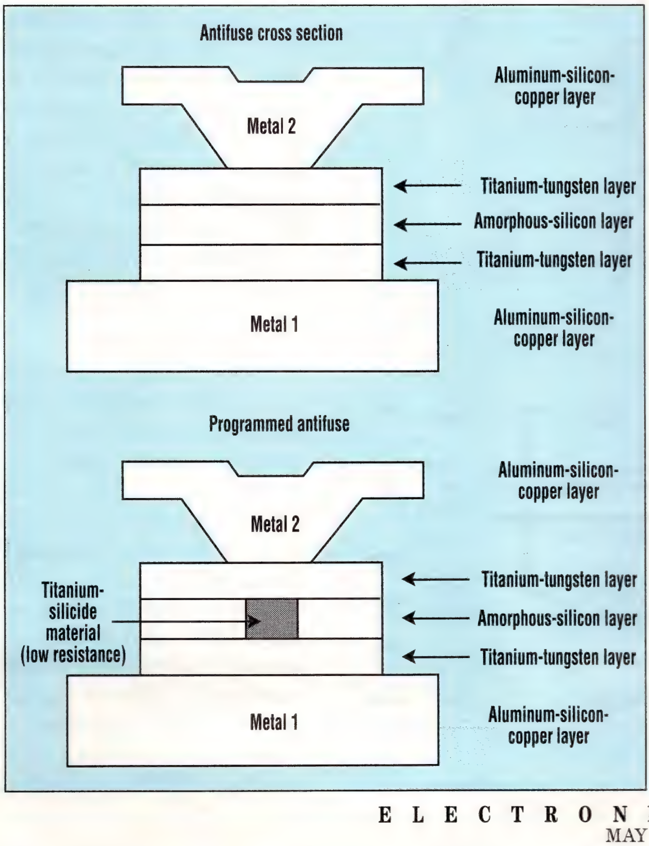
One key implementation of this fuse technology is in UTMC's high-speed 256-kbit PROM. The high-performance, radiation-hardened programmable memory features fully asynchronous operation, requiring no external clocks or timing strobes. In addition, the device offers a maximum address access time of 45 ns and a low-operating current of 155 mA maximum. Capable of withstanding a total of 1×10^6 rads, its survival dose rate is 1×10^{10} rads/s. With its high-density and radiation-hardened characteristics, the result of the fuse technology, it stands out as an industry first.

This technology could find its way into a variety of other, less obvious applications. One such application, security systems, would allow a specific code to be programmed into the fuse. This code could then be used as an access for security purposes. The technology may also find its place with smart sensors. Sensors tend to reach extremely hot temperatures during operation. Products developed using fuse technology integrated with UTMC's radiation-hardened 1.2-µm UTE-R process, though, are less susceptible to increases in temperature. Therefore, products with this technology could be located and operated in close proximity to sensors with minimal degradation.

The major product thrust will be the development of PAL devices in place of standard EEPROM/RAM combinations. Beta-site product development tests are scheduled throughout 1994. Prototypes will be available to all interested parties at the end of June.

Further information may be obtained by contacting United Technologies Microelectronics Center at 1-800-MIL-UTMC or (719) 594-8000.

CHERYL AJLUNI



RISC MICROCONTROLLERS START WITH POWERPC ROOTS BUT GROW IN DIFFERENT DIRECTIONS

As embedded controllers take on more demanding tasks, increased horsepower is needed to keep pace. In robotic and engine controllers, network switches, laser printers, and high-capacity disk-drive positioning systems, optimized 32-bit RISC engines are being called upon to handle compute-intensive needs. One recently developed microprocessor, the PowerPC with its superscalar execution unit and small CPU core area, includes an architecture that makes it an ideal candidate to tackle such applications.

IBM and Motorola Semiconductor, both in Austin, Texas, jointly defined the PowerPC's basic architecture, and now have decided on two different optimized PowerPC architectures for embedded control. The two companies, which presently sell identical general-purpose PowerPC processors aimed at desktop and portable computing applications, recently disclosed their newest embedded-control architectures at last month's Embedded Systems Conference. They will start sampling these chips late next quarter.

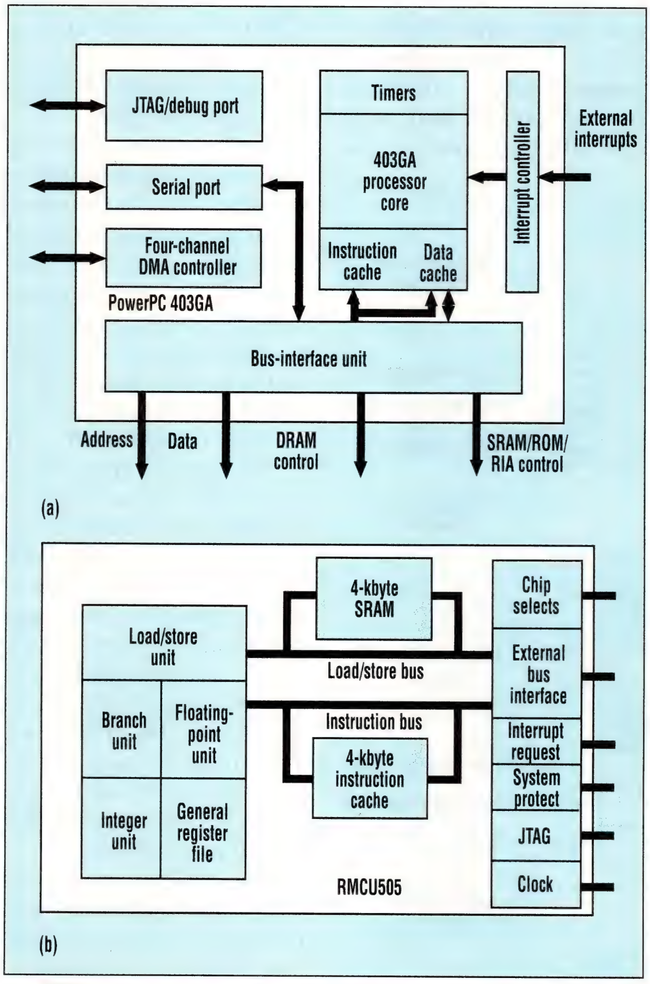
For its PowerPC 403GA embedded processor, IBM decided to forsake the floating-point unit (FPU) that's usually found on the general-purpose CPU and concentrate on integer applications. That decision allowed IBM's designers to shrink the processor core still further and deliver a 585,000-transistor chip that measures just 6.3 by 6.25 mm.

The small chip size also results in relatively low power drain: At a clock frequency of 25 MHz the worst-case power drain with a 3.3-V supply is 1.2 W. However, because the chip employs static CMOS logic, power decreases considerably as the clock frequency decreases. Dynamic power-management schemes as well as hardware support for a power-saving mode are incorporated on the chip.

Taking the FPU off the chip made room for a 2-kbyte instruction cache and a 1-kbyte data cache, a four-channel DMA controller, a serial port, various timers, and an interrupt controller. Also included is a flexible bus interface that supports 8-, 16-, and 32-bit memories and peripherals *(see the figure, a)*.

Designed for operation at clock frequencies up to 25 MHz (initial version), the superscalar execution unit allows the chip to achieve execution rates approaching one instruction per clock cycle. This translates to a throughput of 20 to 25 MIPS.

To reach that throughput level, the internal instruction-queue logic manages branch prediction and folding, as well as instruction prefetching to minimize stalls in the processor's five-stage pipeline. The four-word-deep queue can dispatch up to two instructions per cycle. The integer unit at the heart of the 403GA performs one-cycle arithmetic, shifts, rotations, and logical operations, and four-cycle hardware-assisted 32-bit multiplications and divisions. Supporting the integer unit is a 32-word-by-32-bit register file.



The controller can access and control both SRAM or DRAM external memory, addressing up to 512 Mbytes of main storage. Designers are given lots of flexibility thanks to the bus-interface unit, which can handle a total of eight memory banks. Up to four of those banks can be DRAM and each bank can be individually configured for timing and control requirements so that designers are able to use the optimal mix of memories to meet performance or cost constraints.

Motorola Semiconductor took a considerably different approach: Its RCMU 505 tackles high-performance floating-point-intensive applications thanks to the inclusion of a double-precision FPU. The integer unit, however, is a single-issue processor core, but like IBM's chip, uses a 32-word-by-32-bit register file. To support the FPU, 32 double-precision (64-bit-wide) registers were added.

Larger cache space also was included on Motorola's controller—a 4-kbyte instruction cache and a 4-kbyte static-RAM block *(see the figure, b)*. Although the static-RAM block isn't designed as a cache, it can hold critical data. Because the RMCU 505 addresses up to 4 Gbytes of off-chip memory, it's able to handle large image or data files.

Most of the system support logic IBM included on

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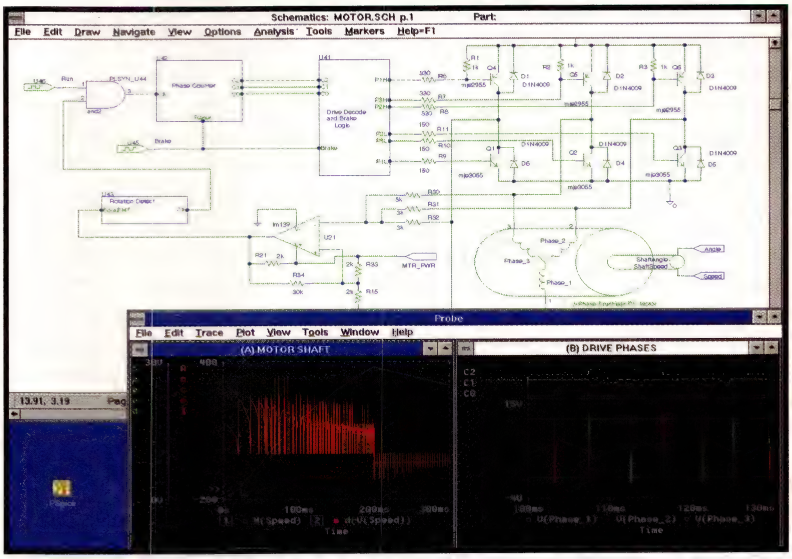
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• Circle No. 305 for IBM • Circle No. 306 for SPARCstation • Circle No. 307 for Macintosh its 403GA was not incorporated into the Motorola RMCU 505. Instead, there are three power-saving modes—sleep, doze, and wait—giving designers the choice of more closely matching the processor to their application. Furthermore, the controller contains a dynamically-scalable clock (with a two-cycle lock time), allowing the system to change the internal clock frequency. This reduces power consumption during non-critical processing periods without stopping the processor.

Like IBM's controller, Motorola's chip will operate from a 3.3-V power supply. In addition, Motorola has indicated plans to up the clock frequency to 40 MHz by 1995.

When running at a 33-MHz clock frequency, the design, based on static logic, consumes less than 700 mW of power (typical), placing the chip's power-consumption level at the low end of the spectrum for 32-bit CPUs. At that speed, the single-issue architecture will deliver a throughput of about 25 MIPS. For applications that demand even lower power-drain levels, a 2.2-V version that operates at clock frequencies up to 25 MHz will be available late this year.

Included on the RMCU 505 are a dozen programmable chip-select lines, each of which is configurable with from 0 to 7 wait states. That flexibility lets the RISC MCU directly control many off-chip peripherals and subsystems without incurring I/O decoding delays. In addition, up to 32 interrupt sources can be handled by the processor rapidly—interrupt latency is less than 750 µs.

As the family broadens, Motorola Semiconductor will incorporate various functions. One is the intermodule bus (IMB), a feature the company includes in its 68300 family of microcontrollers. Once the IMB is on the chip, the RISC MCUs will be able to exploit Motorola's extensive library of peripheral functions already available for the 68300 family—DSP cores, EEPROM blocks, ROMs, timer blocks, serial communication modules, analog-to-digital and digital-to-analog converters, and so on. A next-generation version of the IMB, the IMB-2, is currently being designed. This unit will extend the modular design concept and include multimaster functions to communicate with additional CPUs or intelligent peripherals.

Cost often is a key consideration in the selection of an embedded controller IC. Sometimes, even though a controller chip may cost more than an alternative CPU, it might potentially execute more in the same amount of time. If it's able to do more, additional features could be added to a system, providing product differentiation and significant value-added. One key aspect can be system testing, which both IBM and Motorola addressed by including JTAG interface circuits on their controllers allowing easy testing.

Initial samples of the RMCU 505 in 144-lead plastic quad-sided flat packages will be available in the fourth quarter for about $75 each in 100-unit lots. By 1997, Motorola expects the volume pricing to drop to about $25 each. The IBM 403GA will come in a 160-lead PQFP, with volume pricing in 1995 expected to be less than $50.

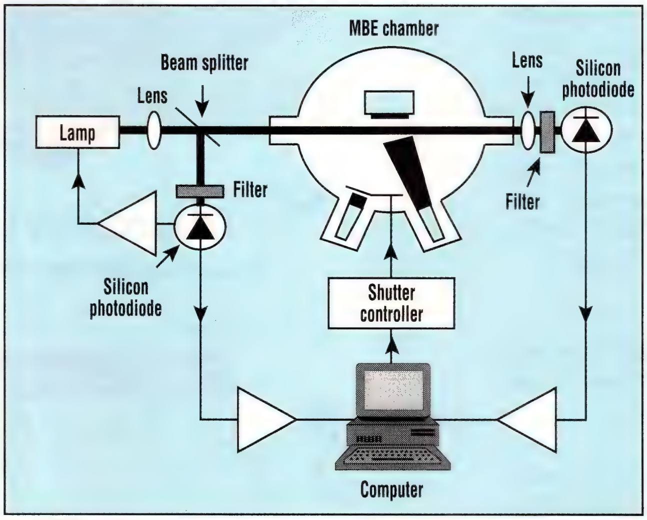
For more information about the PowerPC 403GA, contact IBM at (800) 769-3772. For other information concerning the RMCU 505, contact Motorola's Dick Spilo at (512) 891-3620.

DAVE BURSKY

REAL-TIME MOLECULAR-BEAM-EPITAXY CONTROL SYSTEM YIELDS DEPTH ACCURACY TO WITHIN 0.3%

For years, researchers have tried to come up with a way to control, in real time, the growth rates of devices created by the molecular-beam-epitaxial (MBE) process. The traditional technique for controlling growth—using pregrowth calibrations—isn't accurate enough for the high-precision devices desired. Where the MBE process is being used to grow devices, manufacturing yields for integrated circuits are capped by this lack of real-time control.

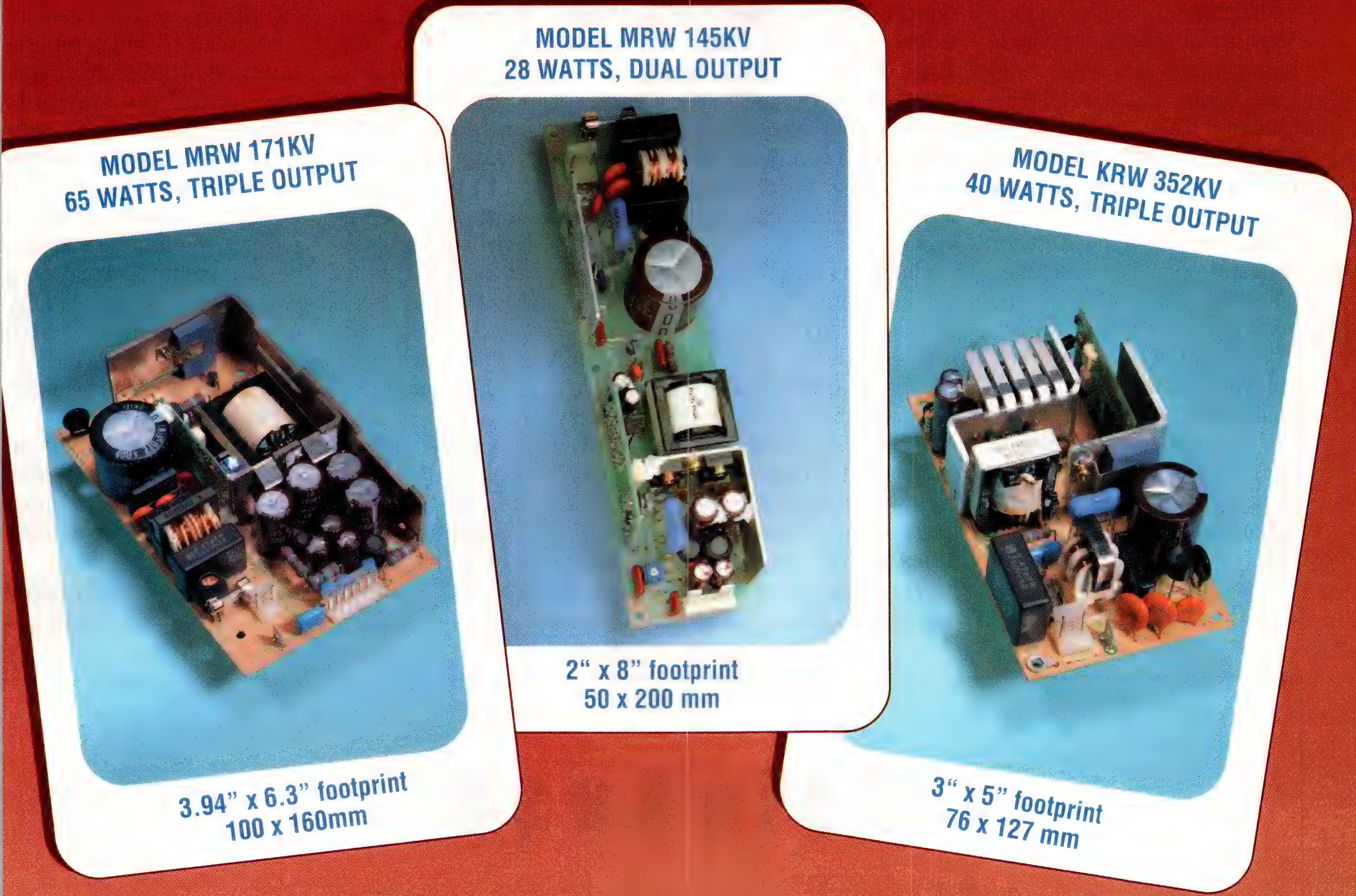
Now, two researchers at Sandia National Laboratories, Albuquerque, N.M., have developed a system that offers real-time monitoring and control of the MBE process' beam to ensure extremely accurate layer thicknesses. The basic premise of the technique isn't new—passing light through the beam to measure its density and velocity. But researchers have been stymied because growth rates must be controlled within 1%, which means the light beam employed must be measured to within about 0.01%.



The new system, however, reported by Scott A. Chalmers and Kevin P. Killeen of Sandia National Laboratories in *Applied Physics Letters* (63:3131, Dec. 6, 1993), was able to control thickness accuracy of the layers to within 0.3%. And it does so without the need for any adjustments during the MBE growth process after initial calibrations.

In its first demonstrations, the system monitored the growth rates of aluminum and gallium metals.

Kepco deals the OEM a powerful hand.



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From that, the two researchers grew a series of nanometer-scale mirrors known as distributed Bragg reflectors.

The system devised by Chalmers and Killeen splits light from a hollow-cathode lamp into two beams, a signal beam and a reference beam. The signal beam passes through a port located in the MBE vacuum chamber, through the elements being deposited for crystal growth, and then out the other side of the chamber *(see the figure)*. There, a photodiode is employed to measure the signal beam.

The reference beam bypasses the MBE chamber and it too is measured by another photodiode. The system continuously measures the ratio of the signal and reference beams to determine the atomic beam's flux, and thus the rate of deposition.

An important aspect of the system is control of the lamp's output, which typically can vary by as much as 10%. Chalmers and Killeen used the output of the photodiode that measures the reference beam as a feedback signal to reduce the lamp's variation to within 0.1%.

Chalmers and Killeen say their demonstration experiment showed that their system can detect and automatically compensate for unintentional as well as intentional variations in growth rate. The result can be layer thicknesses within 0.3% of the target with no adjustments after the initial calibrations.

"Our results show that optical-based flux monitoring can be used as a practical and very flexible MBE control system, one that is based on determining layer thicknesses rather than controlling growth times," the researchers wrote. "Real-time control of alloy composition is possible by simply extending control of the system to the effusion cell temperatures."

Significantly, the new system can be used as an add-on with existing MBE machines, which can cost about $1 million. "Our technique is the only one that is compatible with present MBE chambers as they sit today," says Chalmers. Killeen adds that growth rates can be kept constant or varied during the deposition process. "This makes the system more flexible, and it makes it possible to grow more usable material," he says.

The researchers are moving their prototype to a "workhorse" MBE machine. They plan to add temperature and MBE-shutter control, extend the system to indium, improve the software control, and make the system more robust.

This integration into a more manufacturing-like environment is part of a partnership sponsored by the Advanced Research Projects Agency (ARPA) and several other companies and universities.

For more information on the real-time MBE-growth system, contact Sandia Labs' Kevin Killeen at (505) 844-5164.

JOHN NOVELLINO

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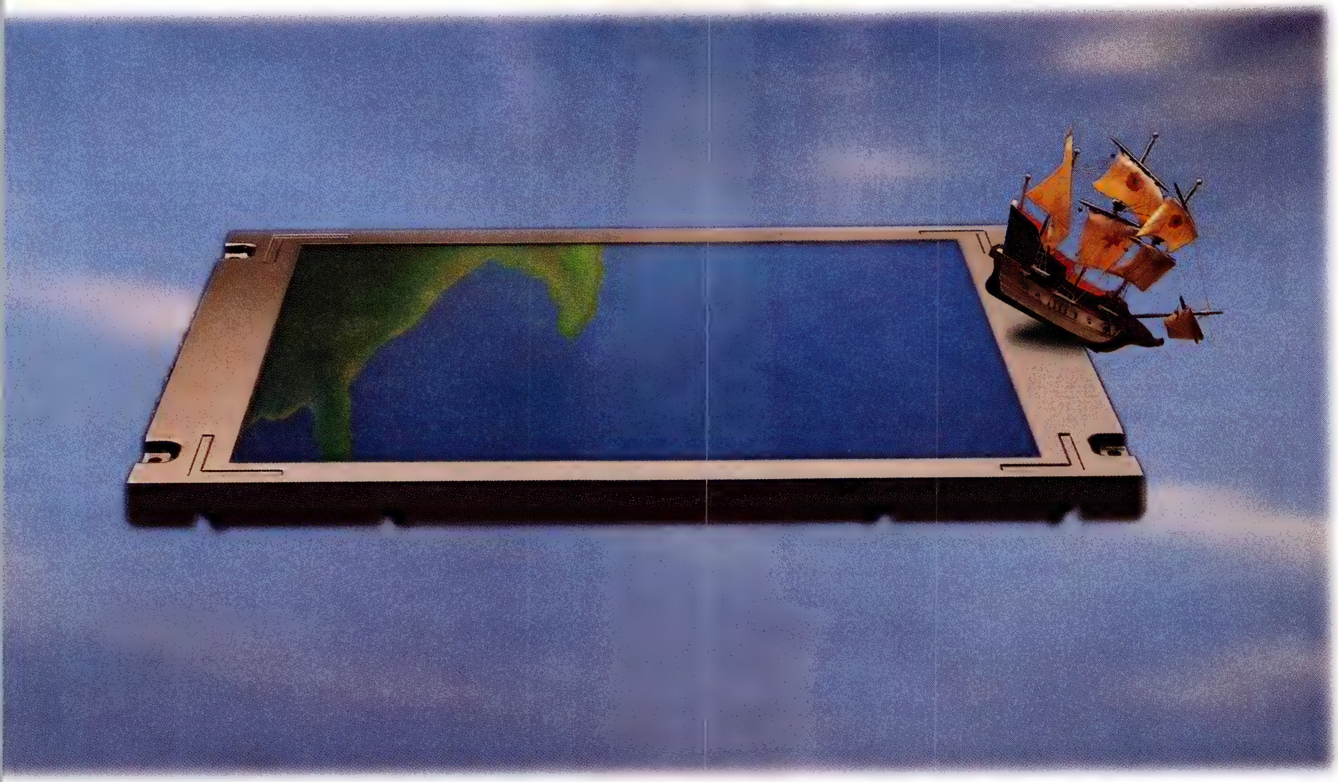

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OPEN-SYSTEMS ALLIANCES ARE FORMED TO DEVELOP INTEGRATED TELEPHONY STANDARDS

There's some good news in store for the growing community of companies who develop advanced telecommunications equipment for the European market: the establishment of the Novell Open Telephony Standards Association (NOTA). The group's primary mission will be to assist the engineering and marketing efforts of companies developing products based around Novell's Telephony Services Architecture. NOTA was founded in February by Novell as well as several major telecom companies, including Alcatel, AT&T, Dialogic Telecom Europe, Mitel, and Philips.

While NOTA's efforts are primarily aimed at Europe, it has a counterpart in the North American region called the "Novell/ATT Telephony Services Early Implementers Program," which was launched in October 1993. To date, 13 private-branch exchange (PBX) manufacturers have signed on, providing NetWare drivers that will help develop applications based on their equipment.

Novell is also providing a family of telephony AppWare Loadable Modules (ALMs). These code modules will expedite the development of networked telephony applications via tools that create the user visual interface and device driver portions of networked telephone software.

The organization's proposed open-system standards permits interoperability between all conforming hardware and software, thereby benefiting both manufacturers and customers. Novell originally developed extensions to its NetWare network software in response to the increased use of personal computers for voice processing and storage, as well as the control of PBX functions.

With a simple, direct link between a local-area-network (LAN) server and a PBX, each system can access the capabilities of the other, creating a powerful synergy. The current suite of NetWare loadable modules permits centralized or distributed call control plus integration of fax, e-mail, video, and voice-mail communications through one or more Novell servers connected to the facility's PBX. Manufacturers of PC-based voice-processing systems also will be able to offer plug-and-play solutions to messaging, monitoring, and control using the new interoperability standards.

By logically fusing the capabilities of their PBX and LAN, customers can easily create custom functions for their systems without having to add expensive adapter cards or other external hardware. One popular example of the power of integrated telephony is auto-

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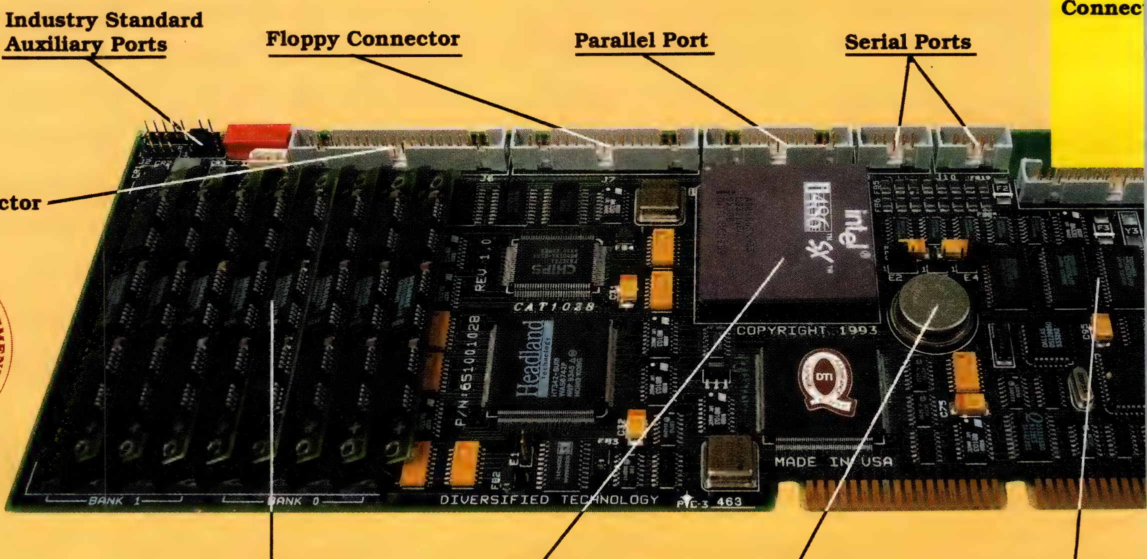
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mated call routing. In this case, the network performs call routing based on information collected from the telephone network and/or data prompted from the caller to direct the call. As the call is sent to its destination, the system provides the answering party with related data files on their computer screen. Employing off-the-shelf programs developed around standard ALMs, users can readily add other features that permit drag-and-drop conference-call setup, as well as multimedia messaging in which fax, e-mail, video, and voice signals are all handled as an integrated package.

The development tools and open-system structure of NetWare-based telephony hardware and software will give market access to smaller companies. Such a package will make it easy to quickly develop new products and services to meet emerging customer needs.

The first version of NetWare telephony services is expected to ship in early April with a per-seat cost of $75 to $200, depending on the order volume and the features selected. In addition, a number of end-user applications from the 24 independent early implementer software developers are scheduled to begin rolling out in April. The PBX and auxiliary equipment manufacturers also are expected to have their respective drivers available in April.

For further information, contact the Novell NetWare products marketing group at (800) 453-1267.

LEE GOLDBERG

STUDY POINTS TO EMI PROBLEMS IN MCM DESIGNS

Circuit designers are becoming much more aware of the effects of EMI on their finished products, especially in this age of shrinking wireless devices. But nowhere do the pernicious effects of EMI create cause for concern more than in multichip modules (MCMs). There, the extremely high density of mixed analog, digital, and microwave ICs can combine with a paucity of established design rules to stir up a nightmarish scenario.

Engineers at Georgia Tech Research Institute (GTRI), Atlanta, have analyzed MCM electromagnetic susceptibility. Their findings may form the basis for a new series of test procedures, simulations, and design guidelines to help MCM designers ward off EMI problems *(see the photo)*.

John Rohrbaugh, a senior research engineer at GTRI, says MCMs someday may turn out to be a relatively inexpensive way to increase packaging density and provide for fast, easy field repair of large systems. That would drive them downward from military and high-end computer uses into the commercial world. But that means designers of commercial systems must beware of a wide range of potential interference problems stemming from injudi-

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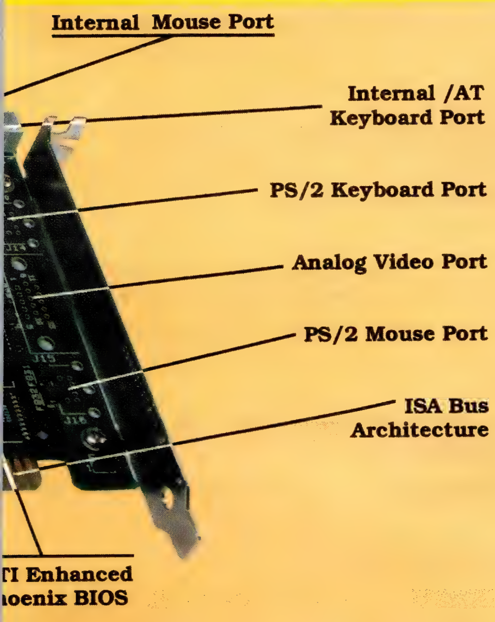

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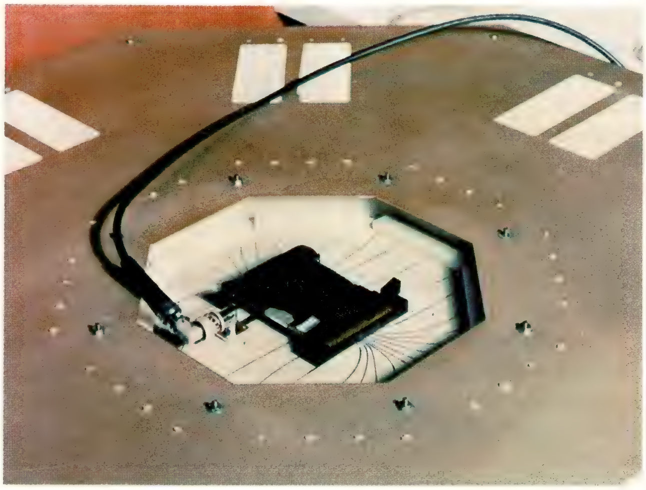
cious design practices involving MCMs. GTRI's research turned up numerous problems, all avoidable if sound EMI design guidelines were followed.

For instance, a transmit-receive module used in radar and communication equipment transferred signals applied to an output pin through the module to all of its input pins. The interfering signals would have disrupted the equipment's operation, and could have activated transmit and receive modes simultaneously.



Besides the potential for interference from signals within the modules, MCMs also are affected by high electromagnetic energy levels in a military environment. "When you have many of these packages inside a box, you have parallel input-output wires that act as antennas for coupling in outside interference," says Rohrbaugh. He believes that the same electromagnetic-compatibility standards established for traditional system circuitry can be applied to MCMs. In tests conducted with the support of the U.S. Air Force Office of Scientific Research and the Rome Laboratory System Technology and Integration Branch, Rohrbaugh and his colleagues determined that standard circuit-simulation software is helpful in analyzing EMI protection for MCMs. The software also helps to identify the most EMI-resistant components.

EMI resistance must be built into MCMs, maintains Rohrbaugh, because adding protection later can increase costs significantly and may also pose daunting technical challenges. It could even lead to complete redesigns of modules.

GTRI is planning to develop design guidelines for MCMs and completely develop analysis and measurement procedures to verify a module's EMI resistance. This could result in a continuing-education short course or a multimedia system with software and drawing tools in one package.

Contact John Rohrbaugh at (404) 894-8235; e-mail is john.rohrbaugh@gtri.gatech.edu.

DAVID MALINIAK

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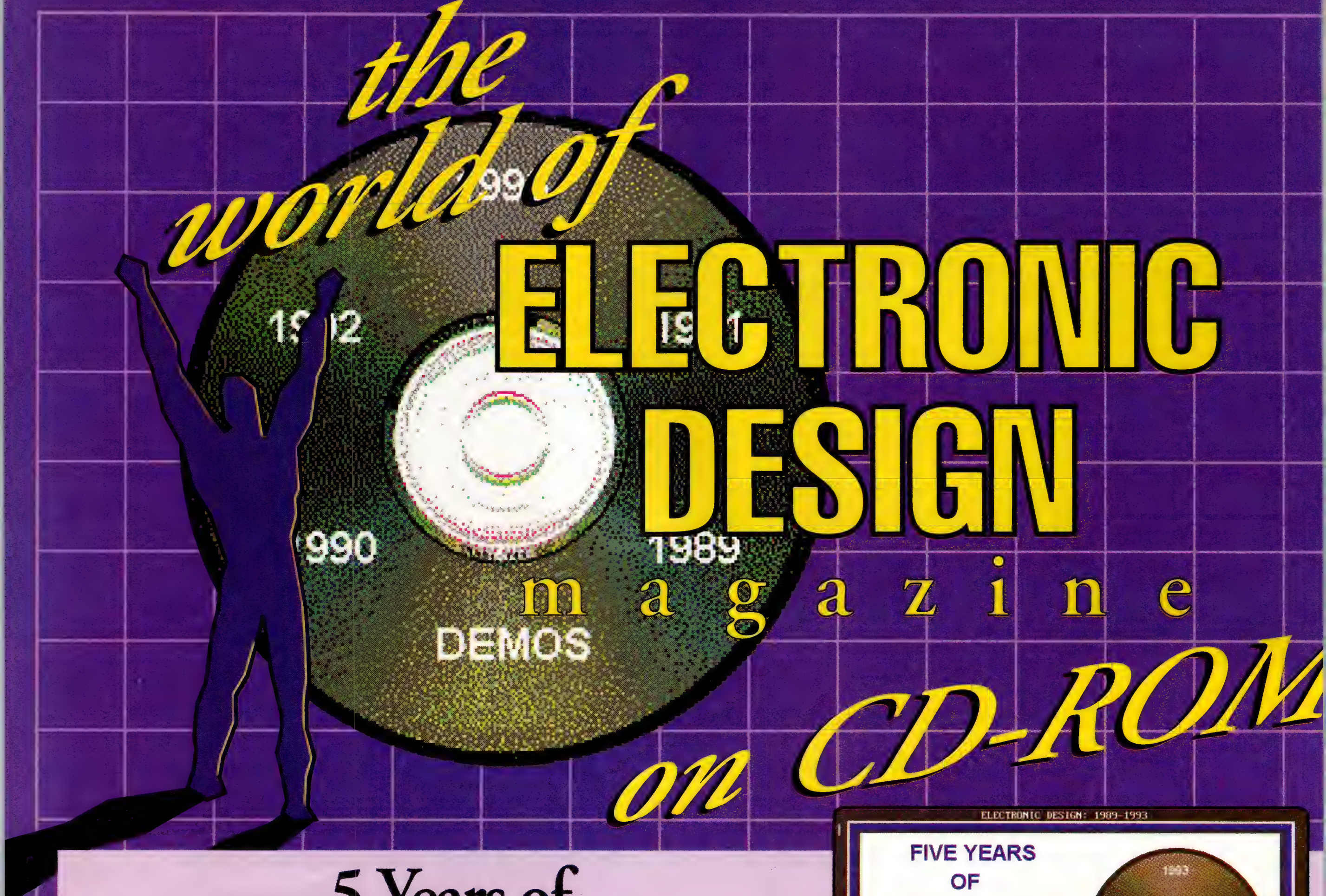

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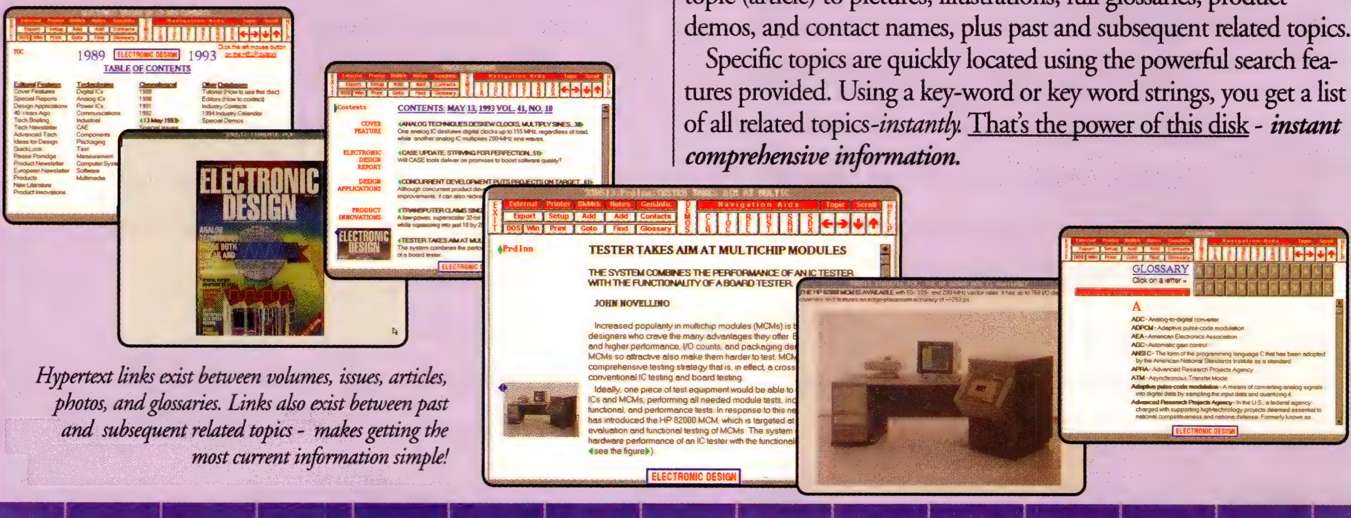

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TESTER TAKES AIM AT MULTICHIP MODULES

THE SYSTEM COMBINES THE PERFORMANCE OF AN IC TESTER WITH THE FUNCTIONALITY OF A BOARD TESTER.

JOHN NOVELLINO

Increased popularity in multichip modules (MCMs) is b… designers who crave the many advantages they offer. B… and higher performance, I/O counts, and packaging de… MCMs so attractive also make them harder to test. MCM… comprehensive testing strategy that is, in effect, a cross… conventional IC testing and board testing.

Ideally, one piece of test equipment would be able to … ICs and MCMs, performing all needed module tests, inc… functional, and performance tests. In response to this ne… has introduced the HP 82000 MCM, which is targeted at … evaluation and functional testing of MCMs. The system … hardware performance of an IC tester with the functional… (see the figure).

THE HP 82000 MCM IS AVAILABLE with 50-, 100-, and 200-MHz vector rates. It has up to 768 I/O … channels and features an edge-placement accuracy of +/-250 ps.

GLOSSARY

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A

ADC - Analog-to-digital converter

ADPCM - Adaptive pulse-code modulation

AEA - American Electronics Association

AGC - Automatic gain control

ANSI C - The form of the programming language C that has been adopted by the American National Standards Institute as a standard.

APRA - Advanced Research Projects Agency

ATM - Asynchronous Transfer Mode

Adaptive pulse-code modulation - A means of converting analog signals into digital data by sampling the input data and quantizing it.

Advanced Research Projects Agency - In the U.S., a federal agency charged with supporting high-technology projects deemed essential to national competitiveness and national defense. Formerly known as

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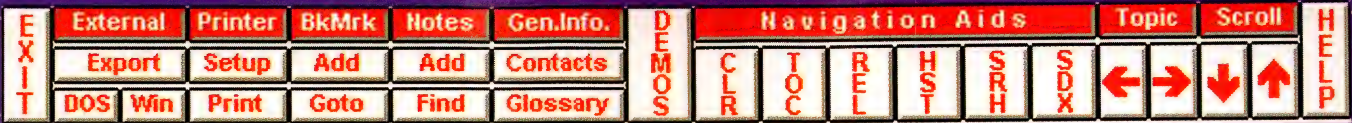

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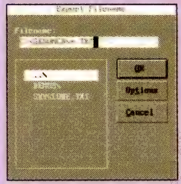

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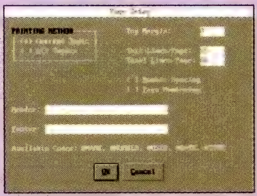

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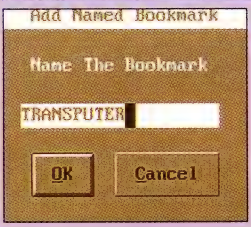
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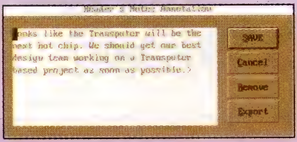
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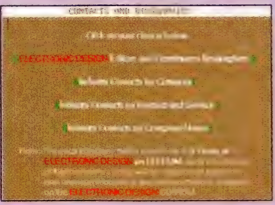

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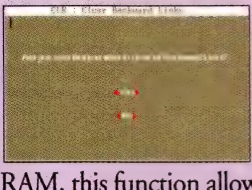

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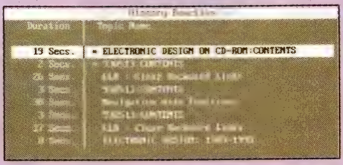
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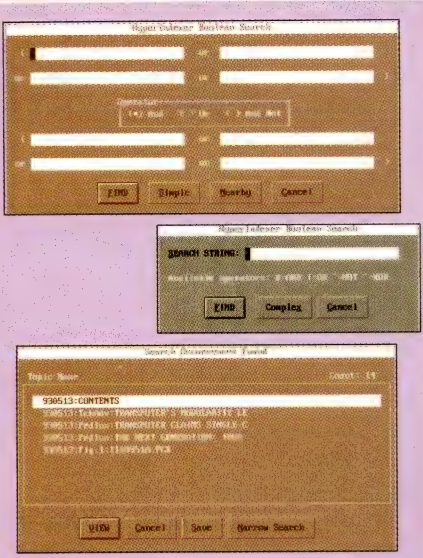
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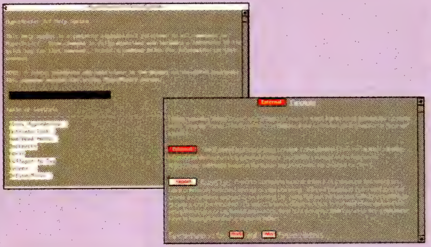

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TWO ADVANCED BIPOLAR OP-AMP ARCHITECTURES BRING GREATER SPEED AND PRECISION TO MICROPOWER SINGLE-SUPPLY IC OP AMPS.

RAIL-TO-RAIL IN-AND-OUT IC OP AMPS RUN OFF 2.7 V

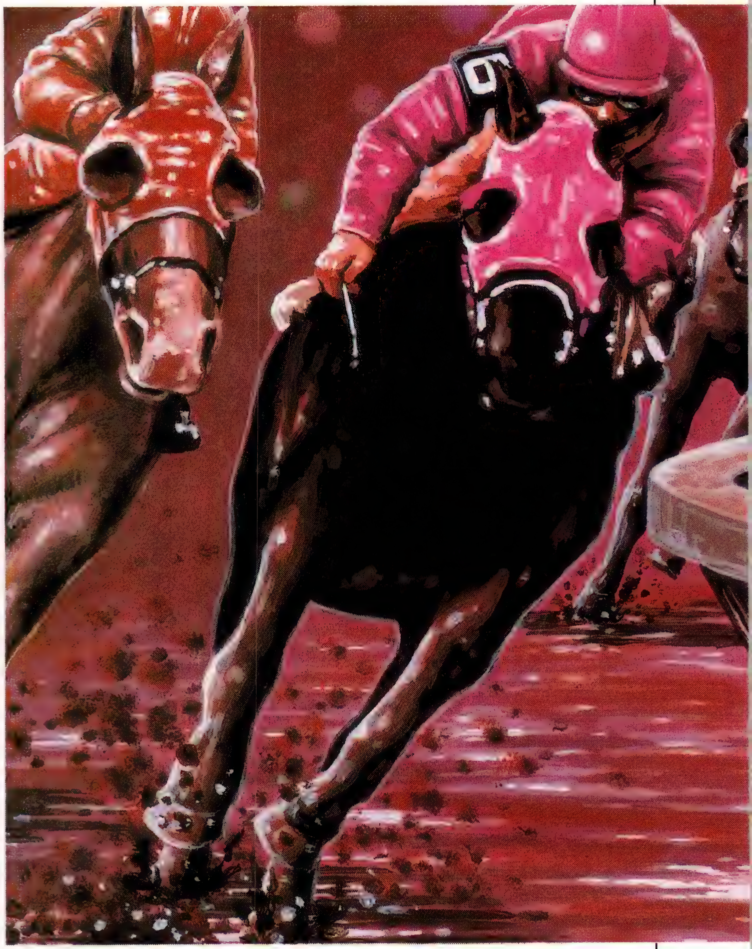
FRANK GOODENOUGH

Conserving system power for better portability, cost, and size has plunged power-supply rails to lower voltages and lower operating currents—without sacrificing performance. Faced with such requirements, both designers and suppliers of analog ICs are being forced to move to devices that can run off single 5-V and even lower-voltage power-supply rails.

Nowhere has this trend been more evident than in the arena of single-supply op amps and comparators. These linear devices (distinct from data converters) present IC designers with a number of challenges. For starters, the ideal single-supply linear IC must offer a "rail-to-rail" input and output, which is no mean trick. A rail-to-rail input means that the input voltage must be able to exceed *both* supply rails without destroying the signal. That is, the input voltage must be able to be more positive than the plus rail and more negative than the minus rail by at least a few tens of millivolts without degrading the common-mode rejection ratio (CMRR) or causing distortion. Moreover, it must be able to exceed the rail by several volts without inverting the output.

A rail-to-rail output means that the op amp's output must have the ability to swing as close as possible to both supply rails (ideally within tens of millivolts) while driving a "practical" load resistance. The output capability of a comparator ideally should be compatible with a common logic standard.

A trio of designers at two companies, Maxim Integrated Products and National Semiconductor, overcame these challenges with new generations of rail-to-rail linear devices.



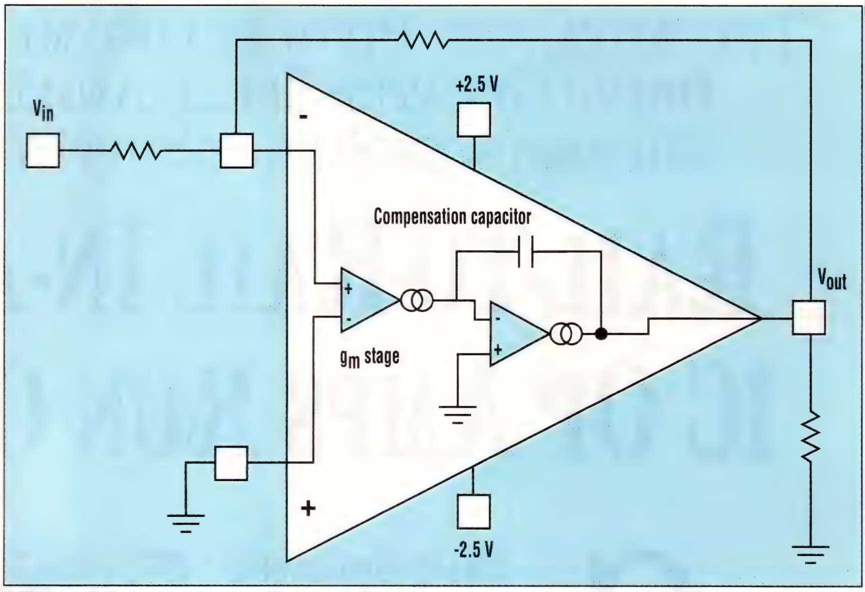
They've developed several op-amp topologies, each loaded with a number of innovative analog circuits that have patents pending.

Unlike the advent of other new op-amp topologies, such as the venerable operational transconductance amplifier or the more recent current-feedback op amp, system designers won't have to learn how to use these new ICs. In fact, in many ways they more closely approach the "ideal" op amp and will be easier to use. For example, they eliminated the signal-inversion problem that occurs when the common-mode voltage (CMV) exceeds the plus rail.

A number of single-supply op amps are available with rail-to-rail output swings, and even some high-speed/wideband units. However, with a few exceptions, they don't offer a rail-to-rail input. Most handle input voltages below the minus rail and a few handle inputs beyond the plus rail—but not both. That's because the former require p-type input transistors, and the latter need n-type input transistors. It makes no difference if the transistors are JFETs, MOSFETs, or bipolar junction transistors (BJTs).

With one exception—a CMOS op amp from National—the few available rail-to-rail-input op amps employ an input circuit that uses both n- and p-type transistors. The p-type devices handle signals close to the minus rail and the n-type devices handle signals close to the plus rail. National's op amp uses an all-p-channel input circuit. A depletion-mode FET handles signals near the plus power-supply rail.

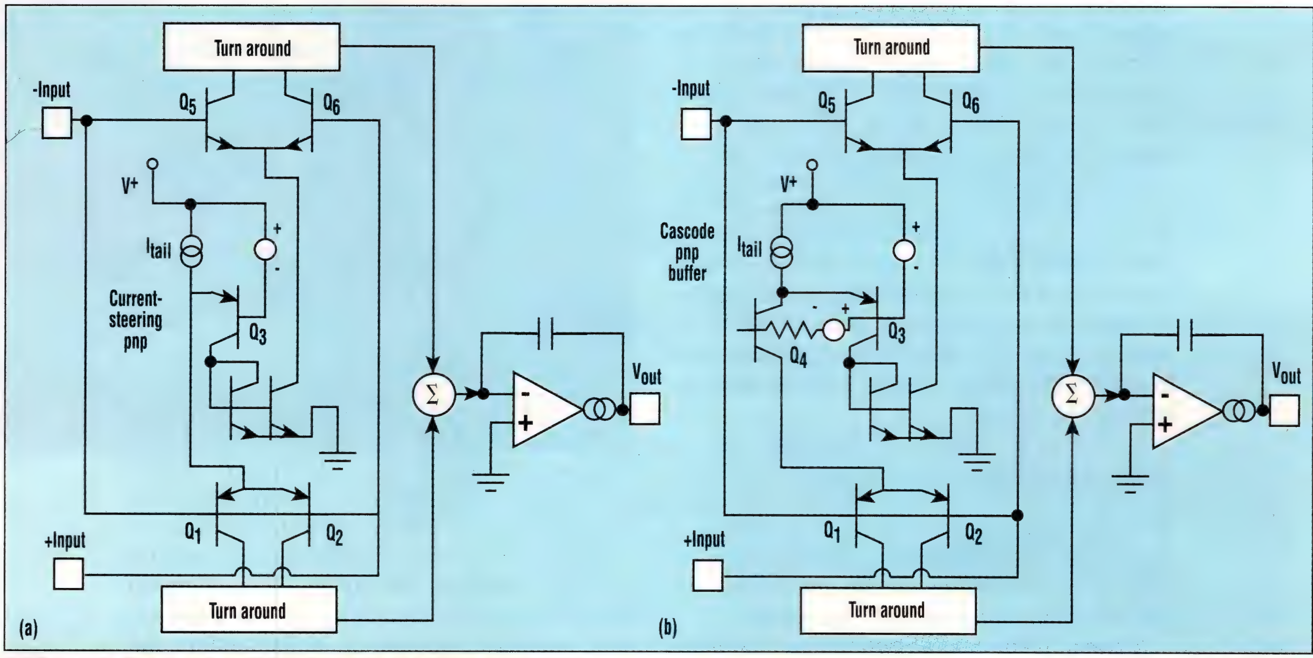
Op amps with n- and p-type devices suffer from errors that occur at the crossover point where operation moves between p- and n-type transistors. The error is a function of the difference between the offset voltages of the different device types that form the differential long-tailed pairs of the input stages.



1. THIS RAIL-TO-RAIL I/O OP AMP DEVELOPED by National Semiconductor replaces the commonly employed voltage-to-voltage input stage with a voltage-to-current transconductance stage.

MEETING THE CHALLENGE

In developing their op amps, National's and Maxim's designers faced yet another challenge: the special output-stage architecture used for rail-to-rail op amps doesn't like to drive capacitive loads, particularly if running at a noise gain of unity (as a gain-of-one follower). The op amps tend to oscillate or at least ring. In addition, all micropower circuits require a trade-off between speed/bandwidth and power. Fundamental laws of physics dictate that higher voltages are needed to drive elec-



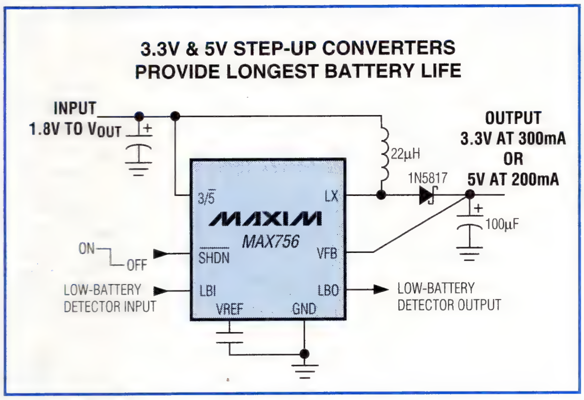
2. TO HANDLE INPUT VOLTAGES BEYOND either supply, rail-to-rail input op amps typically employ a pnp stage connected in parallel with an npn stage (a). Most exhibit switching transients and/or distortion as the signal moves between the two stages. National's LM6142/6144 employ several innovative circuits to eliminate these errors (b).

GET LONGEST BATTERY LIFE BOOSTING 2-CELLS TO 5V OR 3.3V

DC-DC Converters Have 85% Efficiency, 60µA IQ, and 1µA Shutdown

Maxim's new current-limited step-up DC-DC converters extend battery life with the world's best combination of high efficiency, low quiescent current, and ultra-low shutdown current. For example, the MAX756's quiescent current is 60µA, and its efficiency exceeds 85% for loads from 10mA to 300mA—a 30:1 ratio. High 0.5MHz switching frequency and selectable current limit permit use of small (2.6mm high) and low-cost (11¢) inductors. Applications include 3.3V to 5V Converters, Palmtop Computers, PCMCIA Cards, Personal Digital Assistants, and 2-Cell and 3-Cell Battery-Powered Systems.

- **>85% Efficient for 10mA to 300mA**
- **60µA Quiescent Current**
- **1µA Shutdown Current**
- **Uses Small, Low-Cost Inductors**
- **1.8V Guaranteed Start-Up (Operates Down to 1.1V)**
- **Low-Battery Detector (LBI/LBO)**
- **Evaluation Kit Speeds Designs (Order MAX756EVKIT-SO)**



The 8-pin MAX756/MAX757 and MAX856-MAX859 step-up converters draw only 60µA when stepping up from 2-cell battery (1.8V) inputs to 3.3V or 5V outputs, or when boosting 3V supplies.

PART NUMBER	GUARANTEED OUTPUT CURRENT at 5V$_{OUT}$ (mA)	INDUCTOR CURRENT-LIMIT (A)	OUTPUT VOLTAGE (V)	MAX. SHUTDOWN CURRENT (µA)	PRICE* ($)
MAX756	200	1	3.3V or 5V	40	1.95
MAX757	200	1	Adj. (2.7V to 5.5V)	40	1.95
MAX856	100	0.5	3.3V or 5V	1	1.60
MAX857	100	0.5	Adj. (2.7V to 5.5V)	1	1.60
MAX858	25	0.125	3.3V or 5V	1	1.60
MAX859	25	0.125	Adj. (2.7V to 5.5V)	1	1.60

POWER SUPPLIES ANALOG DESIGN GUIDE 4

Data Sheets · Applications Notes · Free Samples

Small 10A Step-Downs Maximize Battery Life at Heavy and Light Loads

Step-Up/Step-Down Converters: 3.3V or 5V$_{OUT}$ from 1.5V to 6.2V$_{IN}$

Compact 8-Pin Solution: No Transformer No External Diode

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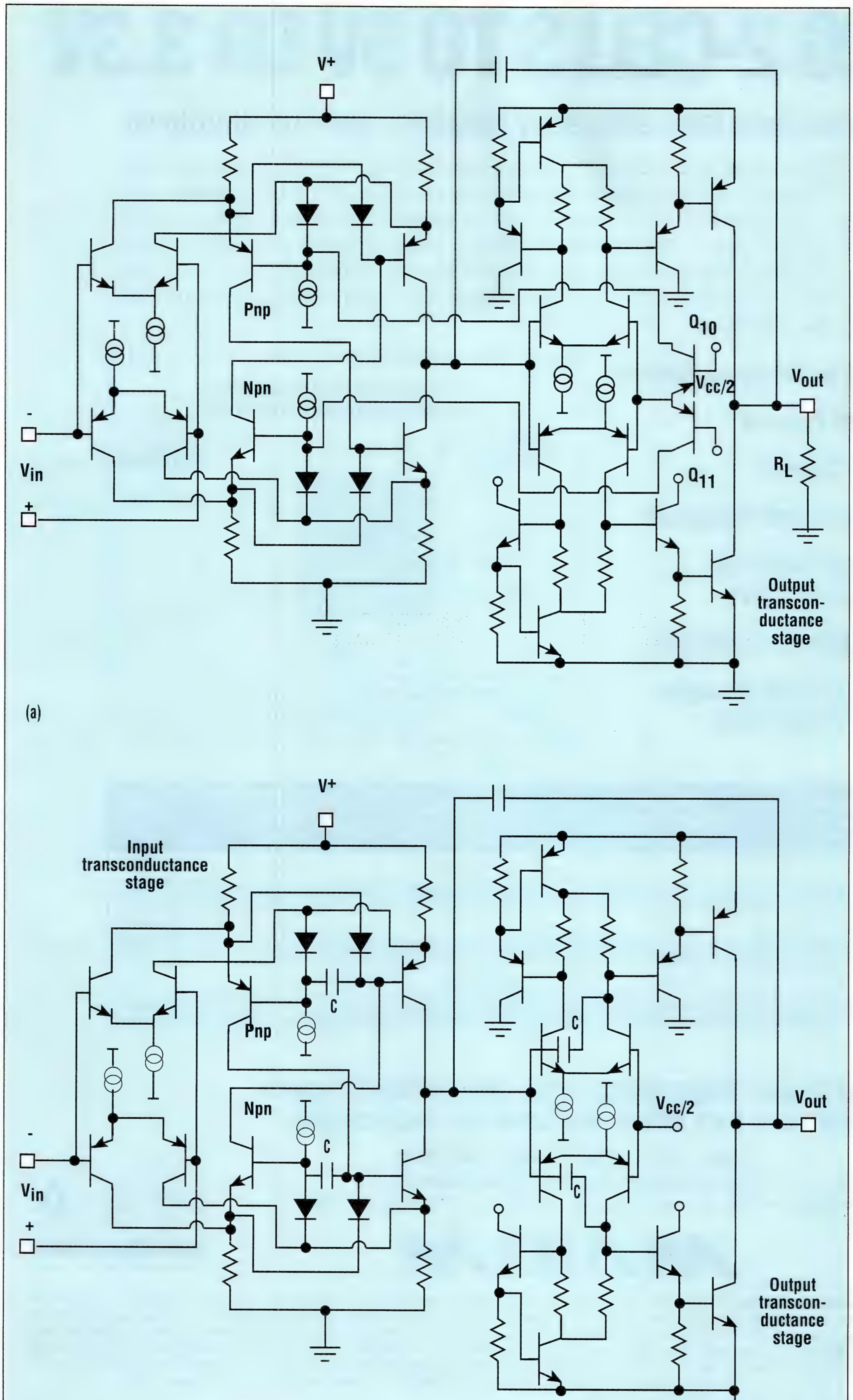
READER SERVICE 146

trons faster for higher speeds/bandwidths. Output-stage design gets particularly tricky when combined with the need to drive a "practical" load of less than several hundred kilohms or even just a few thousand ohms.

From the start of product definition, the initial goals of the designers were to come up with different types of devices featuring different specifications. However, the resultant architectures are basic and can be employed for other designs and even moved to other processes. Don Sauer of National was after a fast/wideband op amp, Paul Crolla of Maxim wanted a fast comparator, and Matt Kolluri, also from Maxim, wanted a precision op amp. The common thread among all three was that low-power rail-to-rail I/O operation from rails below 5 V was desired—without sacrificing one iota of performance.

Sauer's work resulted in National's LM6142/6144 (dual/quad) op-amp family with a typical unity-gain bandwidth of 4 MHz and a gain-bandwidth product of 15 MHz at 20 kHz. The op amps are unity-gain stable driving 1000 pF. Operating from 5 V, each amplifier has a typical quiescent current


V+
Pnp
Npn
Q10
Vcc/2
Vout
RL
Q11
-
Vin
+
Output transconductance stage
(a)
V+
Input transconductance stage
C
Pnp
Npn
C
C
C
Vcc/2
Vout
-
Vin
+
Output transconductance stage
(b)

3. USING a transconductance output circuit to provide a rail-to-rail output from an op amp creates several problems. To eliminate the effect of output loading on open-loop gain, National's LM6142/6144 provide a positive feedback path to the pnp and npn transistors in the intermediate stage (a). Four capacitors around the output and intermediate stages perform compensation and reduce the bandwidth in order to drive a capacitive load (b).

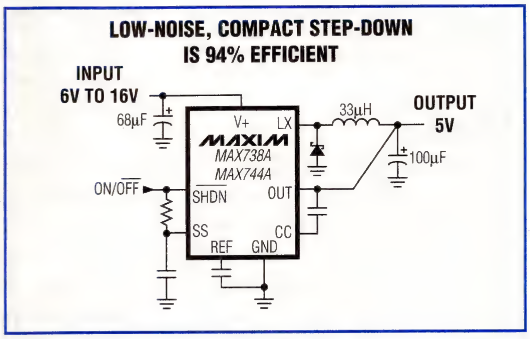
NO SUBHARMONIC NOISE!
94% EFFICIENT DC-DC STEP-DOWNS POWER WIRELESS SYSTEMS

Internal Switches and Surface-Mount Packages Save Space

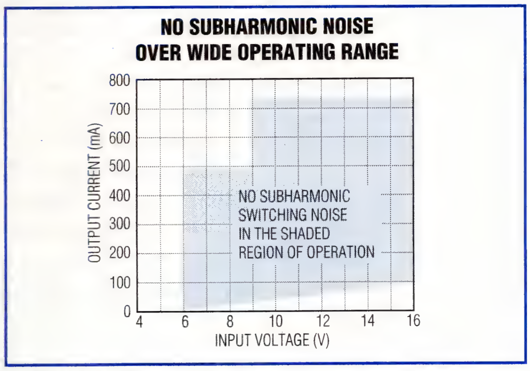
Compact size, battery-saving features, and low-noise make this new family of pulse-width modulated (PWM) step-down DC-DC converters ideal for portable communications and wireless applications. These drop-in replacements for Maxim's popular MAX730-family deliver up to 50% more output current, are free of subharmonic switching noise, maintain up to 94% efficiency, and are lower priced. And, the MAX744A has guaranteed 159kHz to 212.5kHz oscillator limits to avoid interference in the sensitive 455kHz IF band. External component selection has already been optimized to simplify design work.

- **No Subharmonic Switching Noise with Low V_{IN}-V_{OUT} Differentials**
- **88% - 94% Efficiency**
- **Compact SOIC Footprint**
- **Up to 750mA Output Currents, Guaranteed**
- **Logic-Controlled 6µA Shutdown**
- **5V, 3.3V, or Adjustable Outputs (1.25V to V_{IN})**
- **Evaluation Kits Available**†

DEVICE	REPLACES	OUTPUT VOLTAGE	INPUT RANGE	PRICE*
MAX730A	MAX730	5V	5.2V–11V	$2.15
MAX738A	MAX738	5V	6V–16V	$2.60
MAX744A	NEW	5V	6V–16V	$2.90
MAX748A	NEW	3.3V	3.3V–16V	$2.60
MAX763A	NEW	3.3V	3.3V–11V	$2.15
MAX750A	MAX750	ADJ	4V–16V	$2.15
MAX758A	MAX758	ADJ	4V–11V	$2.60

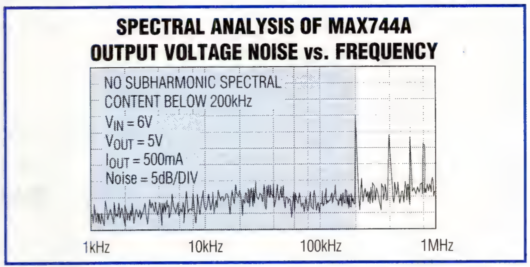


LOW-NOISE, COMPACT STEP-DOWN IS 94% EFFICIENT



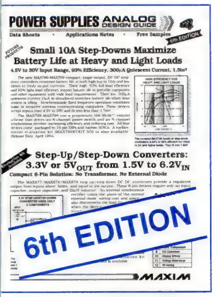
NO SUBHARMONIC NOISE OVER WIDE OPERATING RANGE

The MAX744A exhibits no subharmonic switching noise over a wide input voltage and output current range.



SPECTRAL ANALYSIS OF MAX744A OUTPUT VOLTAGE NOISE vs. FREQUENCY

The MAX744A output voltage noise spectra shows no switching noise below the 200kHz fundamental switching frequency.



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of 650 μA (700 μA maximum). Over a CMV range from 100 mV below the minus rail to 100 mV above the plus rail, CMRR typically runs 80 dB. Minimum CMRR runs 70 and 60 dB for the A and B grades. These values increase by 15 to 20 dB for CMVs between 0 and 4 V.

TEAM WORK

Paul Crolla designed the rail-to-rail input stage that's used by both his comparator family and by Kolluri's op-amp family. The comparators, the MAX941/942/944 (single/dual/quad), achieve a minimum propagation delay of 150 ns (80 ns typical) with 5 mV of overdrive while running off a 3-V rail and drawing just 600 μA. Their guaranteed CMV range runs from 200 mV below the minus rail to 200 mV above the plus power-supply rail.

Kolluri's op amps, the MAX495/492/494 (single/dual/quad) are somewhat slower. They're stable at a noise gain of unity driving 250 pF and have a typical unity-gain bandwidth of 600 kHz while driving 100 pF in parallel with 10 kΩ. Running off supply rails between 2.7 and 6 V, a CMRR of more than 50 dB is maintained from 250 mV below the minus rail to 250 mV above the plus rail. Operating from a 5-V rail, with a CMV between 0 and 5 V, the typical CMRR runs 100 dB, and the minimum CMRR runs 84 dB. Quiescent current per op amp is a maximum of 130 μA from a 5-V power-supply rail.

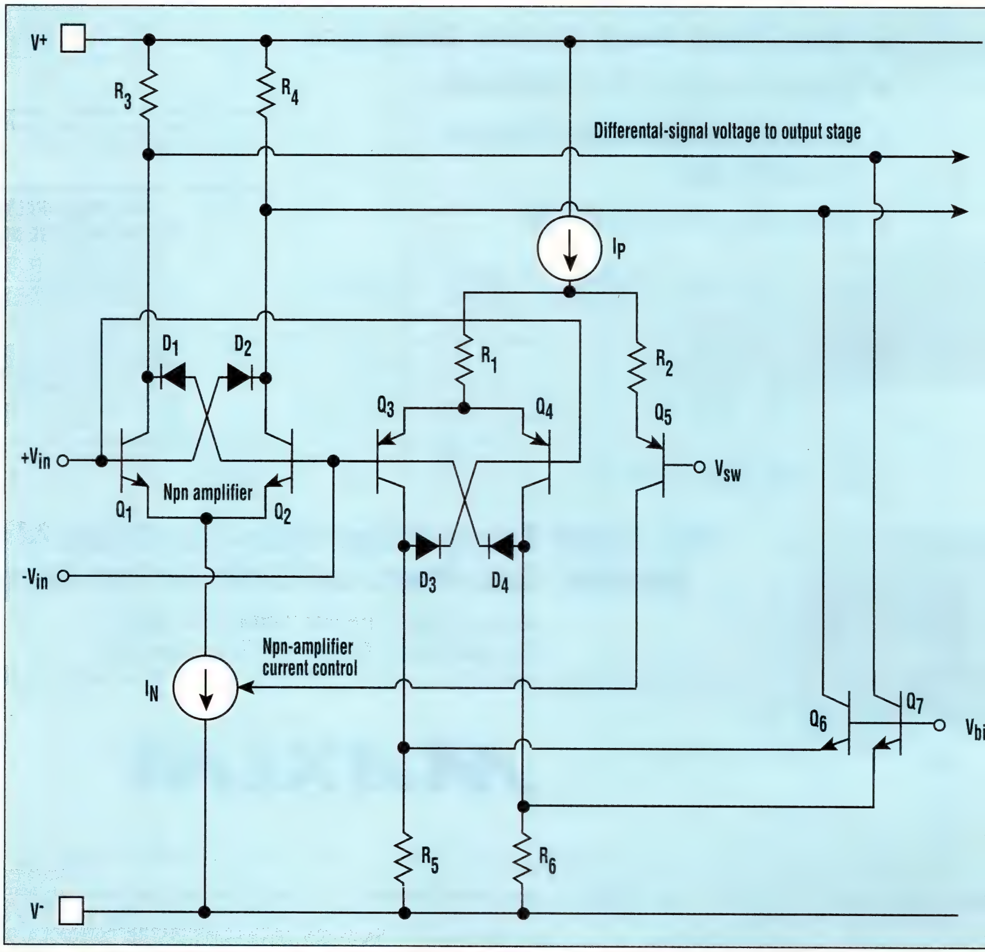
Though many differences exist between the National and Maxim op amps, there are a few similarities beyond their CMV/CMRR specifications. Both are built on complementary-bipolar processes of the kind usually considered as the domain of op amps with bandwidths reaching beyond 100 MHz. However, even here a major difference exists. Maxim's op amps are built on a low-voltage (7-V) process; National's are built on the high-voltage (36-V) VIP II process. As a result, the latter can run off conventional ±15-V analog rails. Minimum supply voltage for the Maxim devices is 2.7 V, National's is 1.8 V.

All three device families offer superior rail-to-rail output capability. The Maxim op amps swing to within 50 mV of either rail while driving 10 kΩ and within 150 mV driving 1000 Ω. Under similar conditions, their outputs are guaranteed to swing within 150 mV and 250 mV of the rails. Thus, even if operating off 2.7 V, their output can put 2.2 V across 1000 Ω. Output swings for the LM6142/6144 are specified with loads of 2000 Ω and 100 kΩ while connected to 5 V. Driving 2000 Ω, their output typically swings between 0.06 and 4.9 V and is guaranteed to swing between 0.075 and 4.89 V. The typical swing driving 100 kΩ runs from 0.005 to 4.995 V.

The major differences between the families become apparent in the trade-offs made for speed versus precision. The LM6142/6144, while no speed demon by today's standards, offers far more performance than most general-purpose op amps. Preliminary specifications are typical, with only the slew rate given a minimum value of 15 V/μs. The output voltage for all ac specifications is 2.5 V p-p.

Typical slew rate runs 18 V/μs, inter-amplifier isolation at a frequency of 1 Hz is 130 dB, and total harmonic distortion (THD) at at a frequency of 10 kHz driving 10 kΩ is –90 dB. Settling time for a 10-V step to within 0.01% is 2.5 μs when running from ±15-V power-supply rails.

On the other hand, while hitched to a 5-V powr-supply rail, the Maxim op amps typically slew at 0.2 V/μs and take 12 μs to settle a 2-V step to within 0.1%. However, driving 2 kΩ and



4. CONNECTING NPN AND PNP AMPLIFIERS IN parallel, which Maxim did for the input stage in its rail-to-rail op amps and comparators, minimizes switching transients and crossover distortion. This is achieved by trimming the offset of the complementary stages.

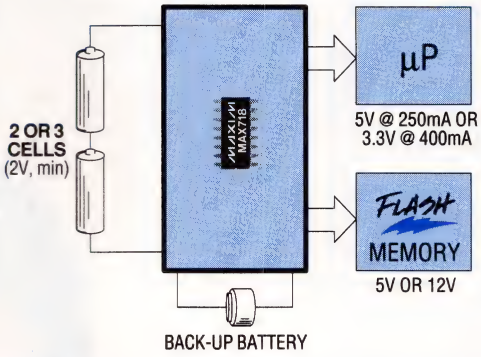
FLASH MEMORY AND µP POWER FROM A 2V BATTERY

Dual-Output Regulator Steps-Up from 2V Battery with 87% Efficiency

These dual-output switching regulators provide an unbeatable combination of high efficiency, low supply current, and small size. They fit perfectly in palmtop and other battery-powered microprocessor system designs. Integrated features include low-output-voltage warning, automatic switch-over between battery power and wall-adaptor power, logic output signalling when wall-adaptor is in use, and a mini back-up switcher powered by the back-up battery to keep-alive memory and clock.

- **Main Output: 3V or 3.3V or 5V**
- **Flash Programming Output: 5V or 12V**
- **87% Efficiency**
- **60µA Quiescent Current (20µA in Shutdown)**
- **Back-Up Battery Switchover**
- **Logic-Controlled Outputs**
- **Narrow 16-Pin SOIC**
- **$5.95***

DUAL-OUTPUT REGULATOR POWERS µP & PROGRAMS FLASH



Part	Main Output	Wall-Adapter Detect Signal	Back-Up Keep-Alive Switcher	Total Shutdown
MAX717	3.3V	YES	YES	NO
MAX718	3.3V or 5V	NO	YES	NO
MAX719	3.0V or 5V	NO	YES	NO
MAX720	3.3V or 5V	YES	NO	YES
MAX721	3.0V or 5V	YES	NO	YES

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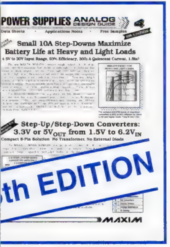
The complete surface-mount MAX718 evaluation kit saves hours of component gathering and board design, layout, and assembly time. Order the MAX718EVKIT-SO, $30.00.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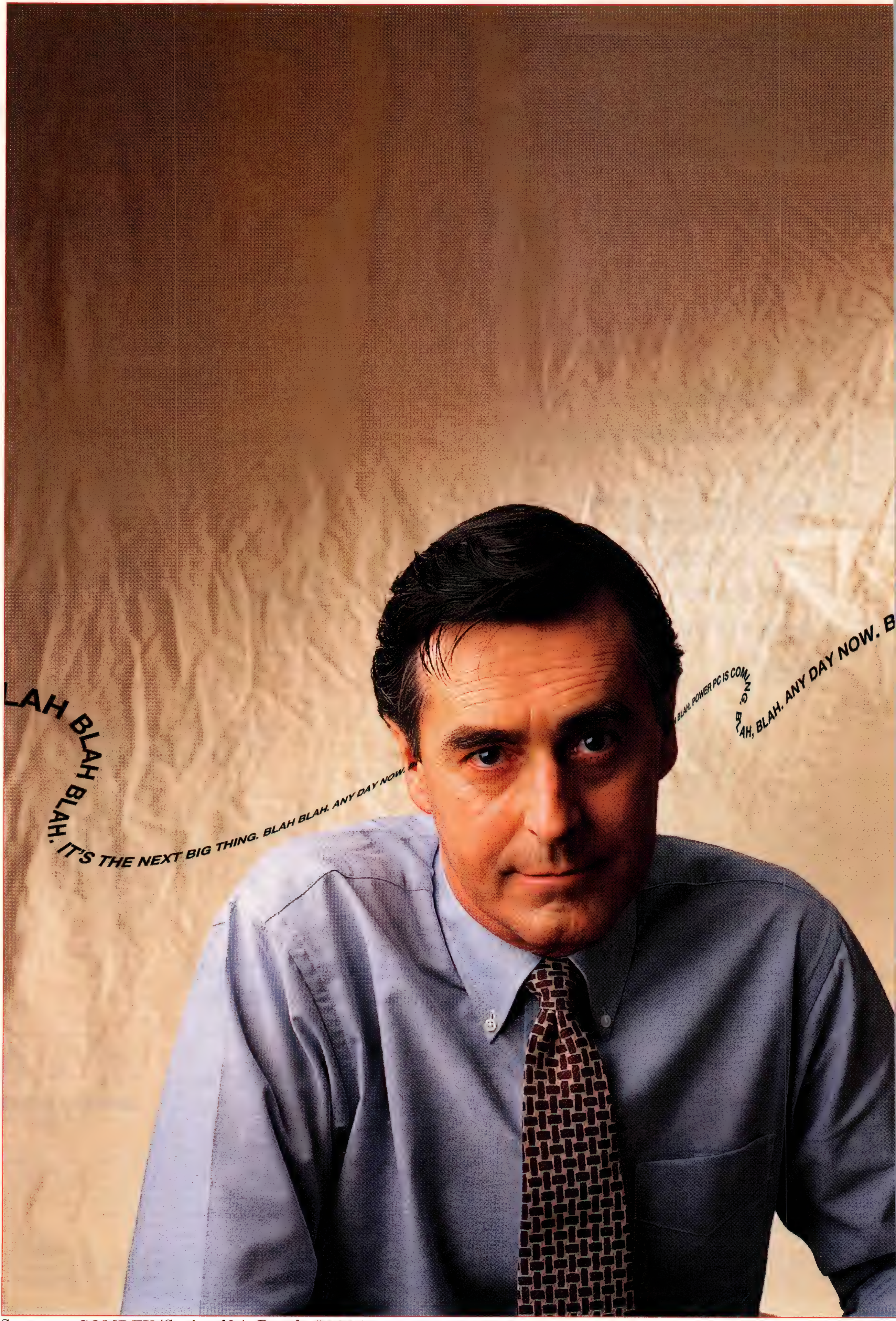
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BLAH. POWER PC IS COMING. BLAH, BLAH. ANY DAY NOW. B

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Everyone keeps saying PowerPC is coming. We believe you'd rather know where it's going.

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Update

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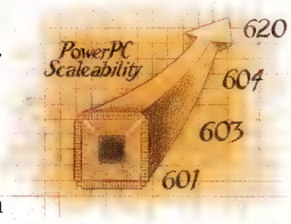
Yet for all this, we at IBM Microelectronics™ Division understand you might still have questions. Not so much about how fast our PowerPC processors run, but how soon you can confidently put them to work for you and your customers.

The answers are closer than you think. As proof, consider that IBM Microelectronics has shipped nearly a half-million PowerPC 601™ processors to the OEM market since September. Which means, by the time you read this ad, they'll already be powering a range of computing products throughout the world. To quote John Dunkle, president of the market research firm WorkGroup Technologies Inc., "It won't take long for the PowerPC to turn up in every segment of the market."

And that's only the beginning. Right now, our PowerPC 603™ microprocessor, ideal for mobile and energy-efficient desktop systems, is available for immediate sampling. By the fourth quarter of 1994, we plan to begin volume shipments of our PowerPC 604,™ a next-generation processor targeted at the high performance desktop market. Close behind will be our PowerPC 620,™ which will offer exceptional performance in high-end workstation and server applications. This impressive timetable is due to the extraordinary scaleability of our PowerPC architecture, a sharp contrast to the limited headroom of CISC-based processors.



Of course, our momentum isn't confined to products. Today, PowerPC processors are poised to run such popular operating systems as AIX,® OS/2,® Solaris,® System 7, Windows* and Windows NT,™ plus Taligent. In the not-so-distant future, PowerPC adopters can also look forward to the PowerOpen™ Environment (POE), a next-generation, standards-based platform.

Need more proof? Well, major application developers like Adobe, Aldus, Claris, Microsoft, Quark and WordPerfect are busy creating PowerPC-based versions this very minute. And current DOS/Windows™ users can already count on state-of-the-art emulation technology for popular applications. Most impressive of all, IBM Microelectronics plans to provide an outstanding array of PowerPC support, including software development tools, evaluation boards and a network of design centers.

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* Not in native mode.

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15 pF with a 2-V p-p signal, THD at a fequency of 1 kHz is typically –80 dB. The larger, higher-current transistors in the National Semiconductor op amps, as might be expected, give those devices lower voltage noise—13 nV/$\sqrt{\text{Hz}}$ versus about twice that for the Maxim op amps.

The Maxim devices offer superior dc specifications. Their open-loop gain, while driving 10 kΩ and sourcing current, typically runs 140 dB (110 dB minimum), and is about 20 dB less (100 dB minimum) while sinking current. For loads as low as 1000 Ω, typical and minimum open-loop gain while sourcing and sinking remain at 120 and 100 dB, and 105 and 90 dB, respectively. Typical and minimum open-loop gain for the National Semiconductor units, driving 10 kΩ, runs 104 and 100 dB, respectively. It should be noted that the National Semiconductor op amps were being characterized as of this writing, so final specifications may improve.

Further indication that the Maxim op amps are aimed at precision applications is seen in their typical and maximum offset voltages, which run just ±100 and ±200 μV. Those of the LM6142/6144 A version run ±300 μV and ±1000 μV, and those of the B version run ±300 μV and ±2500 μV. Not only does Maxim trim the offsets of their op amps, but offset adjustment (null) pins are provided on the single-device MAX495. National's are not trimmed, and speed is hindered due to an input bias current of ±250 nA maximum (Maxim's runs ±60 nA).

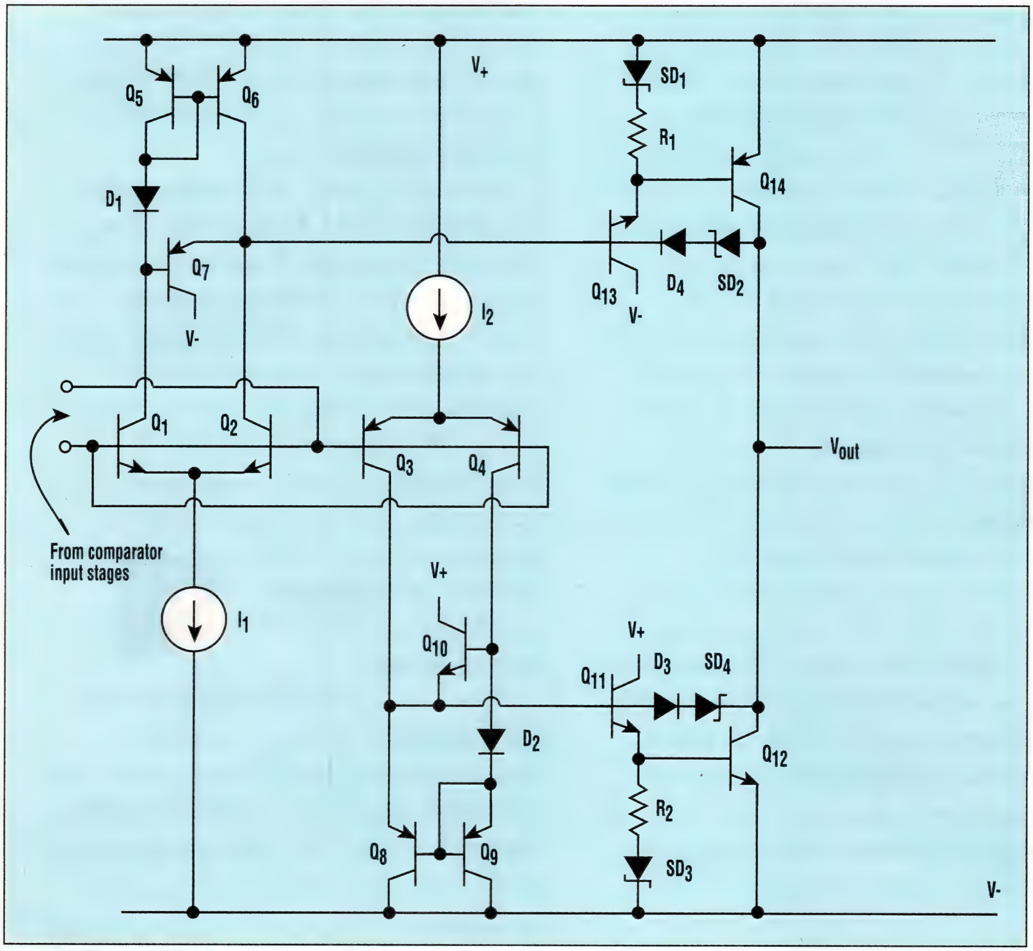
All of these op amps can handle just about any general-purpose application operating from either a single or a split supply. Because the inputs of switched-capacitor ADCs are highly capacitive, they're very useful in driving such converters—particularly those running off 3- or 5-V rails. And, with high output currents and a short-circuit current of 30 mA for both the National Semiconductor and Maxim families, they're handy as line drivers.

A Few Good BJTs

Rather than use a sub-half-micron CMOS process to put a zillion transistors on a thumbnail-sized die, the secret behind virtually all unique analog ICs showcases the results of careful, innovative manipulation of a few dozen transistors. That's the same approach Sauer, Crolla, and Kolluri took in designing their rail-to-rail op amps.

In the typical voltage-feedback op amp, the input stage provides large voltage gain that's usually followed by an emitter-follower buffer for the output current. The LM6142/44 replaces this voltage-to-voltage input stage with a transconductance (G_m) stage *(Fig. 1)*. That is, it converts the input-voltage change to a current change, which isn't converted back to a large voltage change as in standard op amps. Processing the signal as a changing current at a relatively constant voltage charges the internal parasitic capacitors in the IC without degrading the frequency response or causing undesirable phase shifts. This current-mode operation allows the op amp to handle large signals while operating on low supply voltages.

To accept CMVs at least 250 mV beyond either of the supply voltages, the input stage actually consists of two "complementary" input stages: a pnp stage and an npn stage connected in parallel *(Fig. 2)*. Most other bipolar op amps with similar rail-to-rail inputs exhibit large input-stage switching transients. The techniques and innovations used by the LM6142/44 eliminate this problem.



5. THE OUTPUT STAGE of Maxim's rail-to-rail comparator employs a fully complementary circuit. The comparator derives its output from the collectors of the output transistors.

The pnp half of the input stage (Q_1 and Q_2) amplifies inputs from a diode drop below the V^+ supply to about 300 mV below the negative supply. This part of the input stage is similar to the in-

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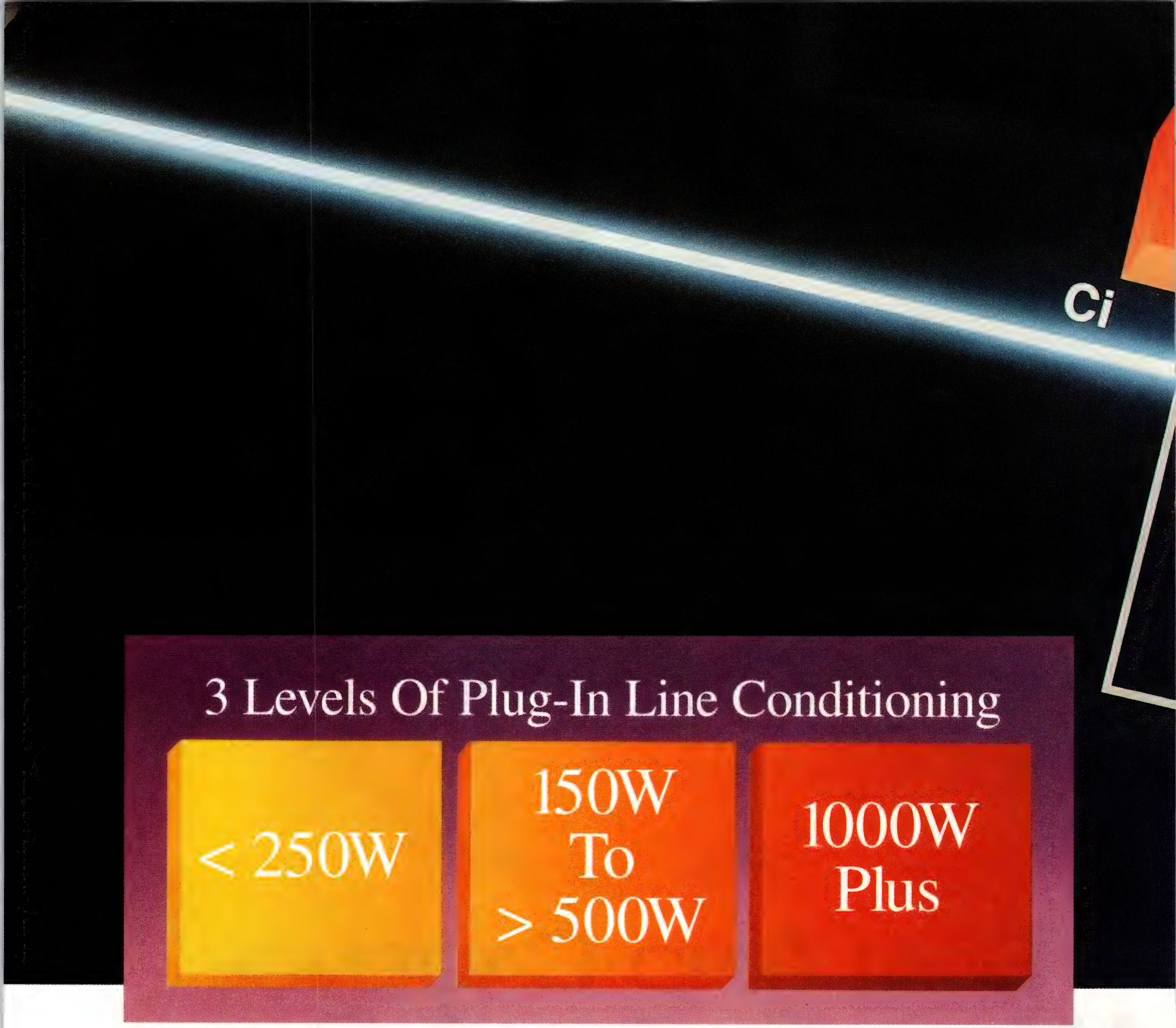
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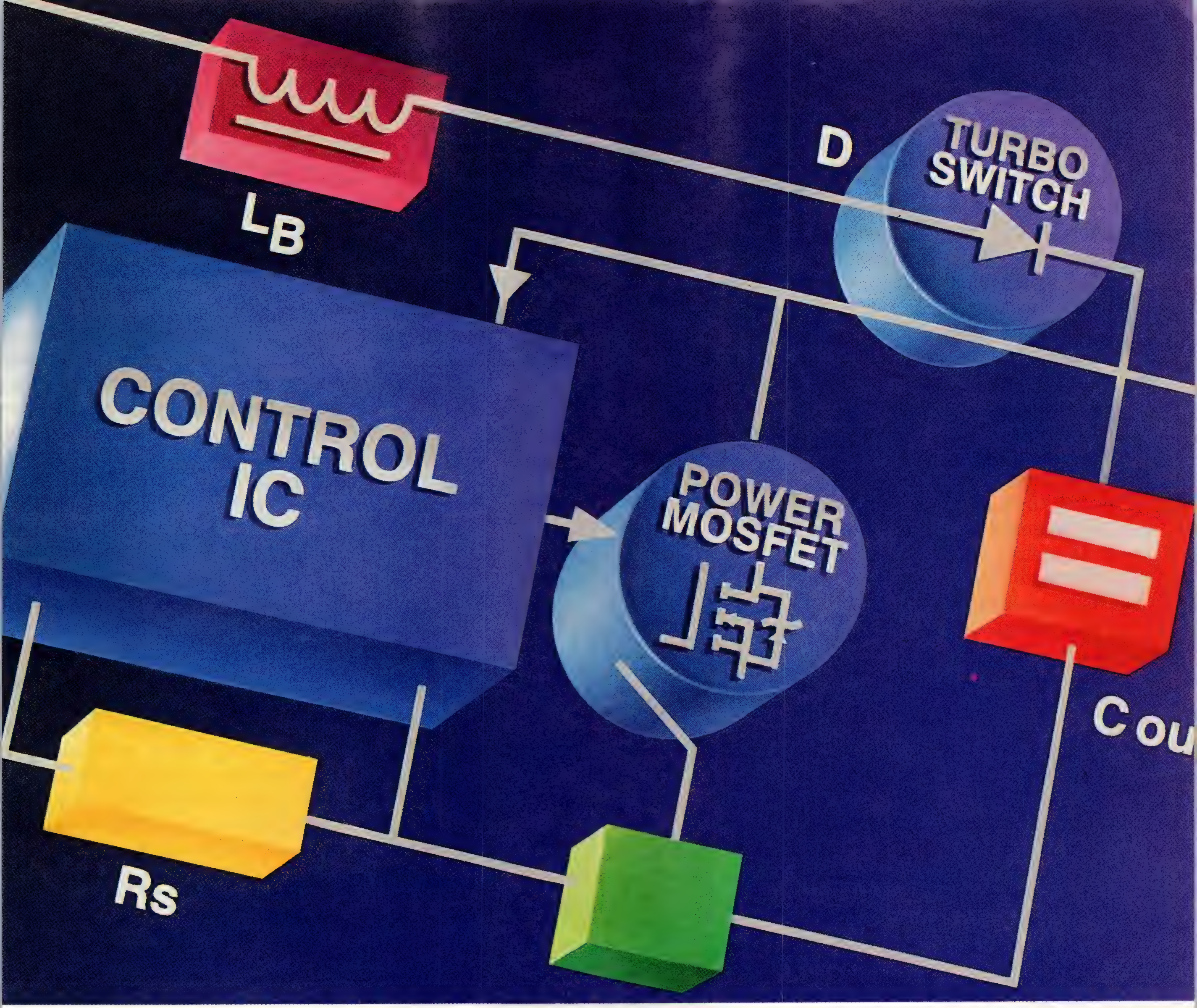

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put of many well-known op amps, such as the LM124. The pnp transistor, Q_3, steers tail currents from the pnp stage to the npn stage (Q_5 and Q_6), which handles the more-positive voltages.

By itself, this design incurs serious limitations. Both the tail current source and the emitter of current-steering pnp-transistor Q_3 see the full CMV. If vertical pnp transistors are used for wide bandwidth, their low emitter-base breakdown voltages limit both supply voltage and differential input voltage. On the other hand, using slower, lateral pnp transistors for their high-voltage capability limits bandwidth and requires high supply currents. In addition, pnp transistors introduce tail-current source errors due to the Early effect.

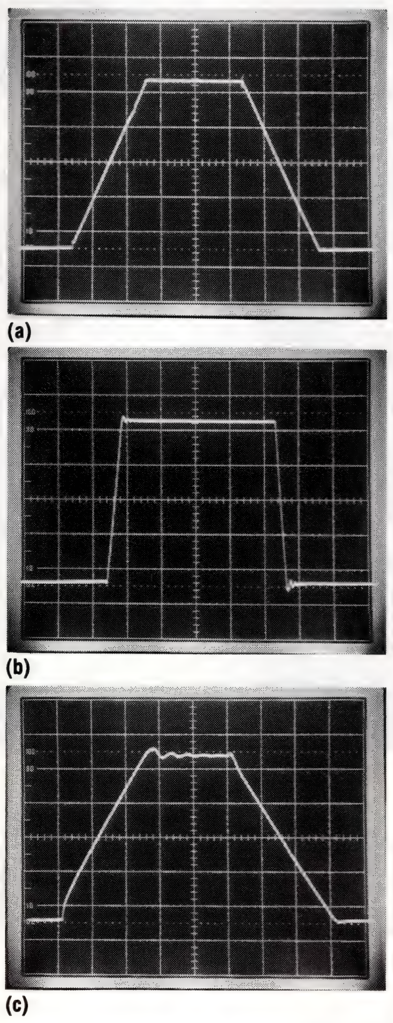
TAIL TWISTING

Adding pnp transistor Q_4 handles these problems. This cascode pnp-buffer transistor has its base voltage biased 120 mV lower than that of the current-steering pnp transistor Q_3. When Q_4 saturates, it diverts the tail current to the npn input stage.

Most common voltage-feedback op amps use an output stage consisting of a complementary emitter-follower buffer whose internal nodes must swing the full output voltage of the op amp. Most output stages, however, can't swing to the supply rails because their output is from transistor emitters. As a result, because the output transistors' bases must always be a diode drop above their emitters, the output can never become more positive than one diode drop below the positive supply rail. Therefore, using bipolar transistors to achieve a rail-to-rail output swing requires that the output must come from transistor collectors like transistors Q_9 and Q_{10}, rather than their emitters *(Fig. 3)*.

Driving Q_9's and Q_{10}'s emitters only requires a voltage swing of about 100 mV. Since BJTs operate well with collector-emitter voltage drops as low as a few millivolts, the output can now swing close to both supply rails. However, the technique raises a pair of problems. If the collectors just provide current, the voltage gain becomes directly proportional to the output load impedance. In addition, even with a small current output, capacitive loads cause 90° phase shifts at the output. Both represent a great way to build an oscillator when an op amp is wanted.

Two innovative additions to the output stage tackle these problems. First, output-loading effects are corrected by an internal dc feedback scheme that uses an internal reference of about $V_{CC}/2$. The reference's current is a function of the output stage current. Instead of feeding the collectors of the reference transistors Q_{11} and Q_{12} to the supply rails, they're fed back to the input stage. There they provide a form of positive feedback that reduces the output load's effect on the open-loop gain.



6. MINIMUM RINGING **characterizes Maxim's MAX392/394/395 op amps, with each driving a 390-pF capacitive load while connected as a unity-gain follower (a). Quiescent current is 130 μA. Under similar conditions, a pair of commercially available op amps with rail-to-rail outputs show significant stability problems (b and c). They feature quiescent currents of 900 μA and 100 μA. Note the ringing at the right-hand edge of the waveforms in (a) and (b), as well as the top of (c). In all three cases, the input is a +0.1 to +4.9-V square wave. The horizontal scale is 10 μs/div. and the vertical scale is 1 V/div.**

Maxim employs similar input-stage circuits for both of its I/O comparators and its I/O op amps *(Fig. 4)*. Rail-to-rail input common-mode range is obtained by feeding the input signal to a pair of complementary differential amplifiers connected in parallel. The npn amplifier of Q_1 and Q_2 handles input voltages close to the plus supply rail (V^+). The pnp amplifier of Q_3 and Q_4 handles input voltages close to the minus rail (V^-). The tail current of the pnp amplifier is switched over to the npn amplifier when the input CMV crosses the switch-over voltage V_{sw}, which is internally set midway between the supply rails.

The CMRR in the crossover region caused by the mismatch in npn and pnp amplifier offsets is improved by adding degeneration resistors R_1 and R_2, and by trimming the offset of both circuits on-chip. Diodes D_1-D_4 prevent output-signal phase inversion if an input is overdriven beyond the limit of the common-mode range.

The differential voltage from the npn input amplifier is taken from resistors R_3 and R_4. The differential output of the pnp circuit is taken from R_5 and R_6. In the comparator design, the pnp amplifier forms a folded cascode with transistors Q_6 and Q_7 and the resulting output current is summed directly with that of the npn amplifier at R_3 and R_4. The op-amp design uses a folded-cascode architecture for both npn and pnp amplifiers. The summing nature of the input stage results in constant transconductance for any value of input CMV.

Circuit design topologies for the op-amp and comparator output stages are very different, due largely to the nature of output-signal compatibility. The output stage for the op amp consists of an integrator block with boost circuitry. This allows the output pnp source transistor to drive a load impedance very close to either supply rail.

The output stage for the MAX941/MAX942/MAX944 comparators is fully complementary *(Fig. 5)*. After amplification in the input stages, the signal in the form of a differential voltage is fed to the bases of long-tail differential pairs Q_1/Q_2 and Q_3/Q_4. The long-tail pairs transform a signal voltage into output current.

Proof of the pudding is said to be in the eating. For an op amp, the "eating" can be shown with oscilloscope-screen photographs *(Fig. 6)*. They depict the stability of Maxim's op amps relative to two currently available rail-to-rail micropower op amps. All three are operating from a single 5-V power-supply rail while connected as a potentially unstable unity-gain follower (noise gain = 1) and driving a 390-pF load.☐

PRICE AND AVAILABILITY

The Maxim MAX495/492 single/dual op amps come in 8-pin plastic DIPs, SOICs, and CERDIPs. The quad MAX494 comes in the same package versions, but with 14 pins. Plastic-package devices are rated for commercial and extended industrial temperatures. CERDIPs handle military temperatures. Equivalent devices in the MAX941/942/944 family of single, dual, and quad comparators come in similar packages. In quantities of 1000, pricing for the op amps and comparators starts at $1.50 and $1.40 each, respectively.

Maxim Integrated Products Inc., 120 San Gabriel Dr., Sunnyvale, CA 94086; Steve Pratt, (408) 737-7600. **CIRCLE 511**

The National LM6142 dual op amp comes in 8-pin plastic DIPs and SOICs. Its quad sibling comes in the same 14-pin packages. All devices are rated for the extended industrial temperature range. In quantities of 1000, A and B grades of the dual go for $3.15 and $2.10 each, respectively. In similar quantities, A and B versions of the quad LM6144 go for $4.88 and $3.26 each, respectively. Fully-883-compliant military versions will be available by year's end and rated for the military temperature range.

National Semiconductor Corp., 2900 Semiconductor Dr., Santa Clara, CA 95052-8090; Dennis Galloway (marketing issues), (408) 721-2885; John Christensen (applications), (408) 721-6815; Marc Murphy (883 devices), (408) 721-7047. **CIRCLE 512**

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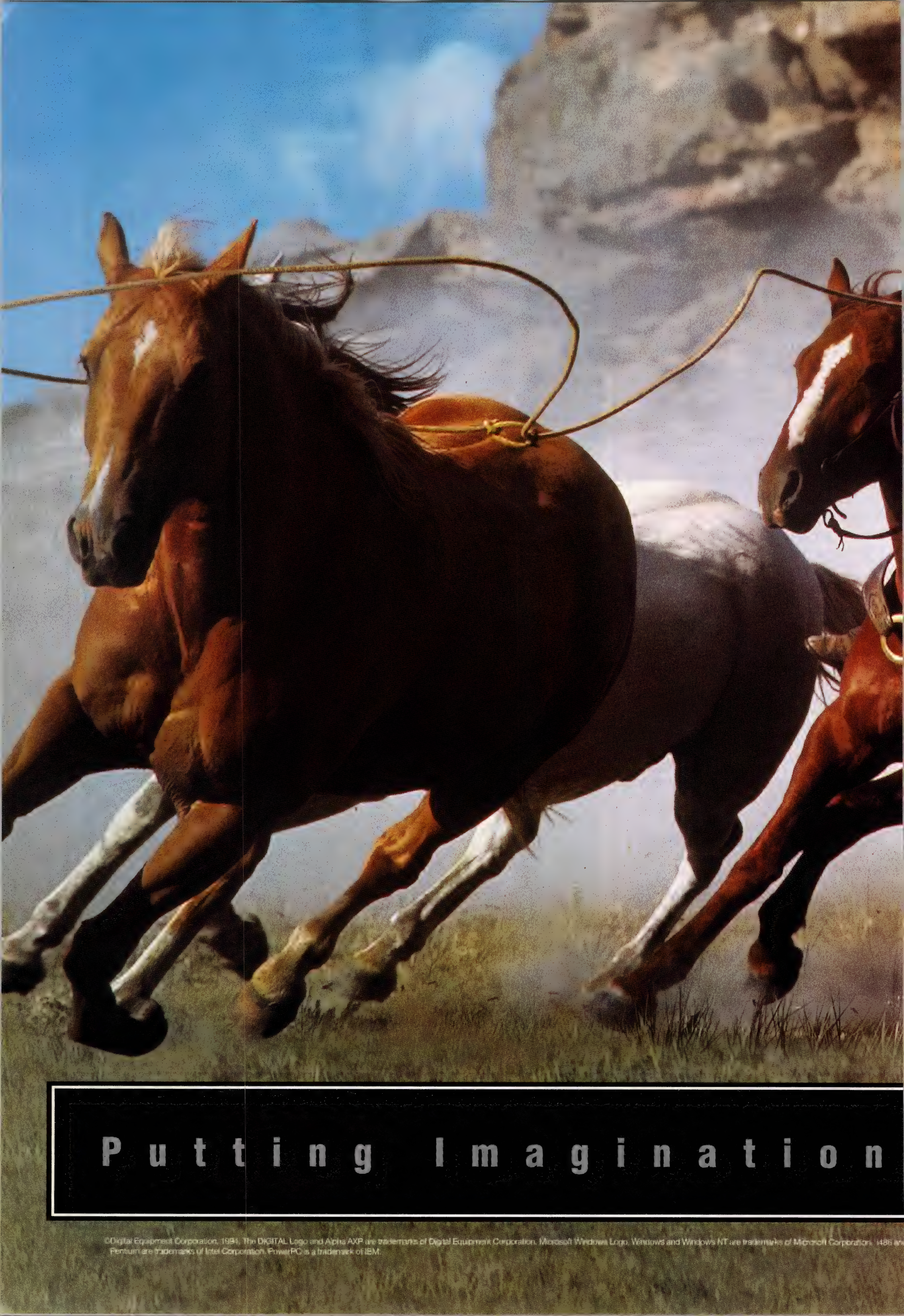

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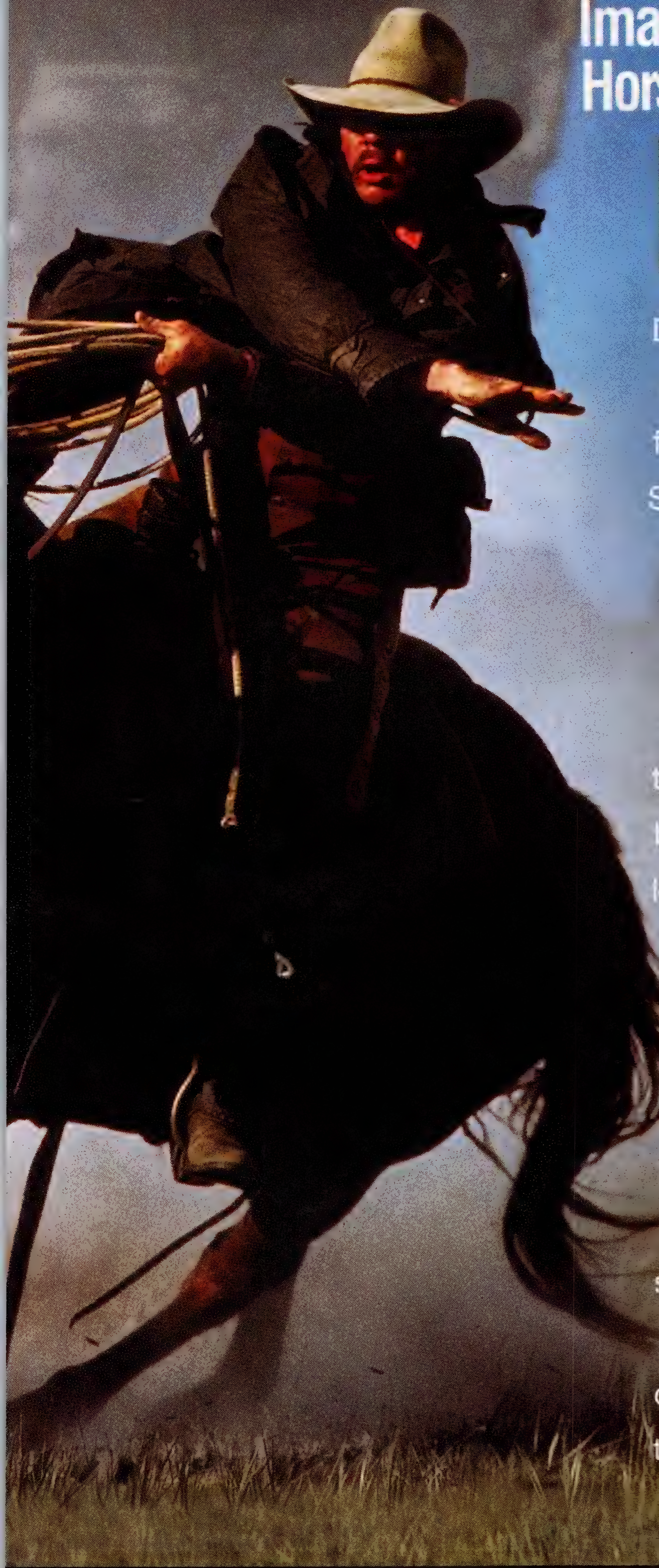

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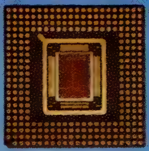

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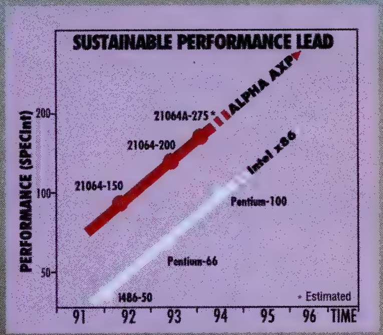

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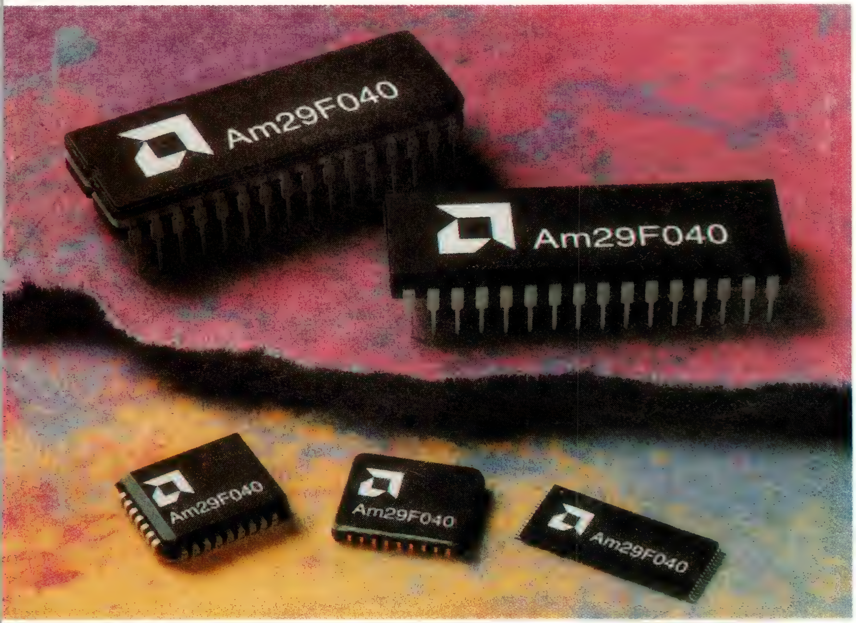

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INNOVATIVE FLASH MEMORIES MATCH DRAM DENSITIES

AVAILABLE WITH A CHOICE OF FEATURES, FLASH MEMORIES ARE FINDING HOMES IN MANY SYSTEMS.

What the industry now loosely refers to as flash memory is the culmination of over a decade of development in electrically reprogrammable nonvolatile memories. Today's flash memories deliver densities comparable to dynamic RAMs, with a number of firms producing 16-Mbit devices in limited quantities and descriptions of 64-Mbit prototypes raising eyebrows at research conferences.

Devices with 16-Mbit densities are becoming invaluable in a broad range of systems—from storing updatable firmware inside a PC or industrial product, to serving as a solid-state replacement for a disk drive. The term "flash," although today a hot buzzword, can find its roots back in early days of the original metal-nitride, NMOS, electrically alterable, read-only memories *(see "The origins of flash," p. 72).*

To optimize flash memory for potential applications, designers have taken two basic architectural directions: NOR-cell-type and NAND-cell architectures. The former, employed in "standard" flash memories, is addressable just like EPROMs and ROMs. These chips incorporate the typical address, data, and control lines that permit random reads and block writes, and will find use in applications that require RAM-like access times of 60 to 250 ns.

The NAND-cell architecture is optimized for long block reads rather than random-access operation. Such an approach serves it well for file- and program-storage applications, which typically contain long sequential strings of words. These architectures often have initial read access times of tens to hundreds of microseconds. Once data is accessed, transfers can take place at several hundreds of kbytes per second *(see "The differences between NAND and NOR flash memories", p. 80).*

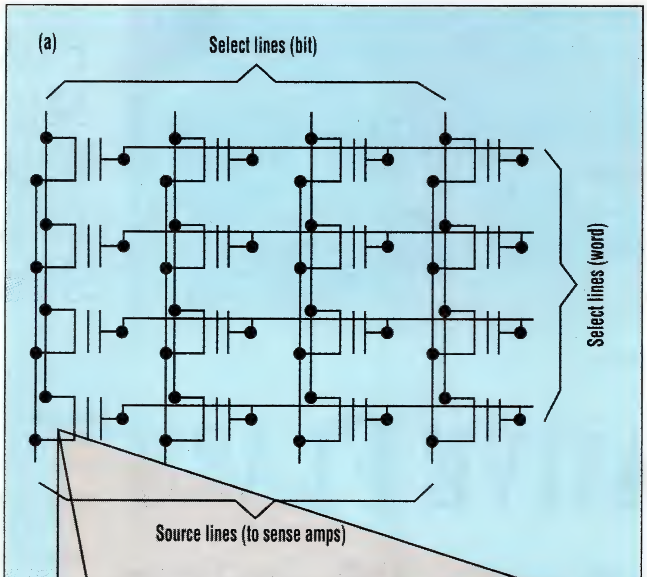
Flash-memory suppliers are adding features that will make the chips easier to use, simpler and faster to program, and more "tuned" to specific applications. For instance, the latest generation NOR-based flash memories usually can interrupt the storage cycle so that the host can perform a read operation. This prevents the host from stalling because it can't access the desired data.

Other features include the ability to internally queue instructions to speed reads or writes, on-chip page buffers to accumulate new data to be stored at read-access-like speeds, and programmable word widths on the I/O port (pin-selectable as 8 or 16 bits). And, since many of the flash chips are aimed at battery powered memory-card and other systems, many new flash designs have special low-power standby modes to reduce power consumption while idling.

Protecting data that's stored in flash memories from accidental or inadvertent overwrites is another key issue. For a significant degree of protection, many newer flash memories can write-protect blocks of the on-chip memory. Also, some flash memories include a form of password protection, where the host is required to send a predetermined pattern to "unlock" the memory, which then makes it possible for writes to take place. Although this scheme adds some overhead, it provides the best protection against unwanted writes.

The guaranteed endurance of flash memories (the number of times a system can write data to a cell and still have a guaranteed 10-year data-retention time) ranges from a low of about 1000 cycles for memories that need minimal updating, to over 100,000 cycles for chips that are updated regularly. Additional improvements in oxide quality should lead to flash devices with guaranteed 1-million-cycle endurances within the next year or two. Currently, Intel's recently released 16-Mbit chip is the only one that guarantees 1 million cycles, although several companies claim their flash chips will typically endure that number of store cycles.

Many manufacturers also are trying to lower the operating voltage levels from the nominal 5 V to 3.3 V for reads. At 3.3 V, internal transistor threshold voltages must be lowered to compensate for the lower supply voltage. A novel scheme developed by Intel does lower those voltages, yet it still allows the chip to operate from the higher supply voltages if 3.3 V isn't available. On-chip circuits sense the input supply and programming voltage levels, and then internally switch several circuit paths to activate appropriate charge pumps, optimizing the memory operation for the applied voltage levels.

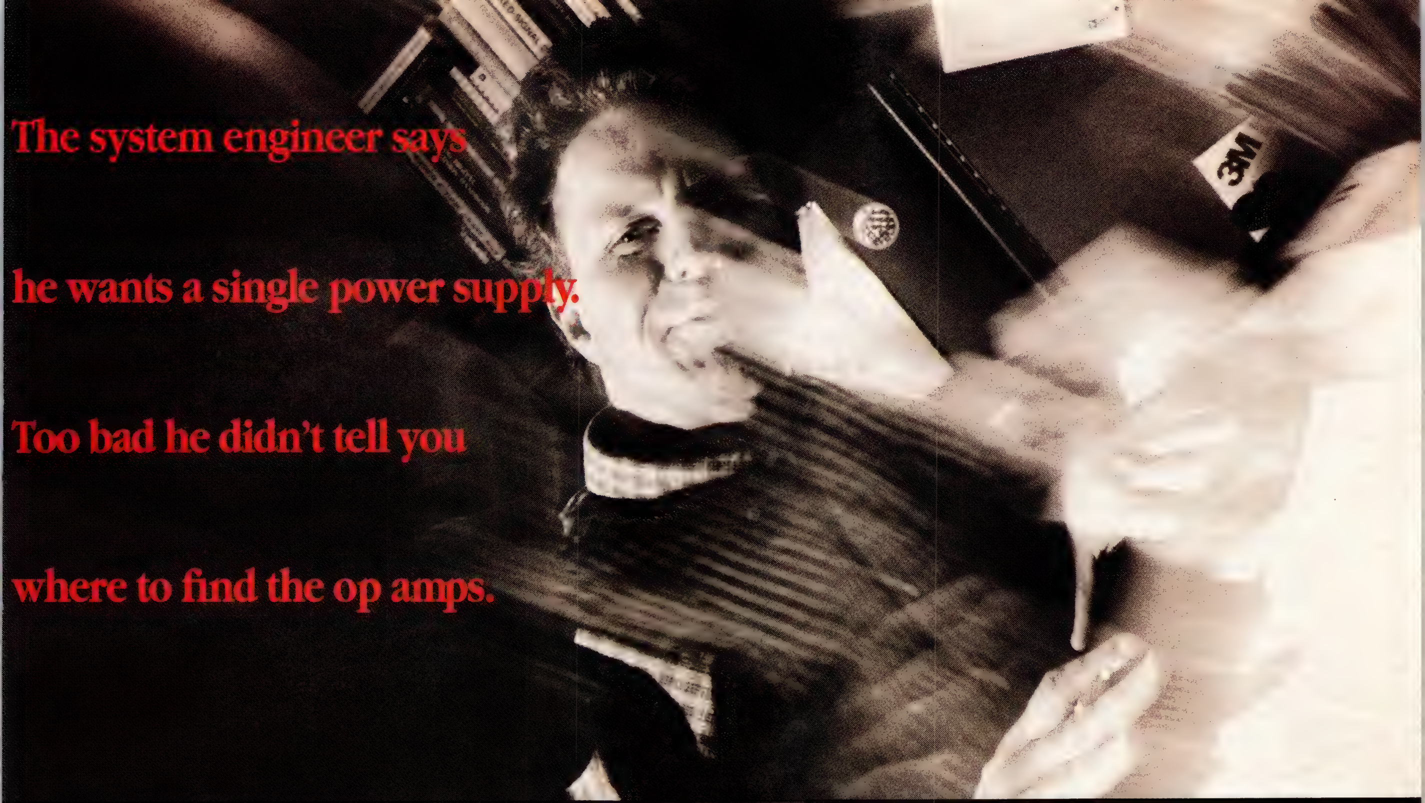


1. THE SIMPLE NOR STRUCTURE used by flash-memory arrays will create very dense chips (a). Each storage transistor in the array (inset) looks very similar to the floating-gate element used in UV EPROMs. During programming, a negative charge is built up on the floating gate to limit the current through the transistor. In the alternative EEPROM-cell structure, two transistors are basically merged into each transistor site (b). One transistor controls read and the other controls write operations. Consequently, each can be optimized, minimizing the current drawn by the chip.

The scheme, dubbed SmartVoltage, will be added to Intel's 2-, 4-, and 16-Mbit flash memories, and will allow a single device to give users multiple read/write voltage options. However, unlike other single-supply 5-V flash memories, which combine supply and programming-voltage inputs onto a single pin, Intel will continue to use separate power-supply and programming-voltage input pins (like its FlashFile and BootBlock memories). Such an arrangement lets Intel offer several options for optimal performance.

To get the most performance, designers would employ 5 V for reads and add the 12-V level for the shortest store time. To achieve moderate performance, both the power supply for read operation and for slightly slower store operations can be set for 5 V. Finally, for lowest power drain, a 3.3 V can be used to minimize active power for reads, and a 5-V level would supplement the supply when a store operation must be done. Designers at Intel also expect to eventually trim the read power-supply level to just 2.7 V.

The NOR-type memory cell, as found in UV-EPROM storage arrays, is a very simple architecture that lends itself to high-density arrays *(Fig. 1a)*. Such a cell can be constructed using a single-transistor storage element similar in struc-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OP	113	213	413		•	•	•			75	4.7	±40	1.75	3.4	Lowest noise and drift
OP	183	283		•	•	•	•			1000	10	±25	1.5	5	5 MHz from +3 to +36V
OP	90	290	490	1.6	•	•	•			150	60	+13/-7	0.015	0.02	Precision micro power
OP		291	491		•	•		•	•	700	21	±10	0.35	3	Low power R-R I/O
OP		292	492		•	•	•			800	15	±8	1.4	4.5	Low cost
OP		295	495	•	•	•	•		•	300	45	±18	0.15	0.075	Accuracy and output drive
AD	820	822		•	•	•	•		•	400	16	±30	0.8	1.9	FET Input
SSM		2135			•	•	•			1000	4.7	±40	1.75	3.5	Excellent for audio
AMP04					•	•	•			150	25	±15	0.7	0.3	Easy-to-use +5V inst. amp
AD626				•	•	•		>		250	250	15	0.23	0.1	Low cost diff. amp

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Atmel, one of the largest manufacturers of two-transistor cell structures, claims some significant advantages in using such a cell. For starters, because one transistor serves as the read gate and the other as the store control, each can be optimized to do the best job *(Fig. 1b)*. That, in turn, minimizes the area per cell and the amount of current needed to program each cell. The lower the current needed to program each cell, the easier it is to include the programming-voltage bias generator on the chip. On top of that, if the bias generator is on the chip, the off-chip power supply of 5 or 3.3 V also can be used as the programming voltage (V_{PP}). As a result, Atmel was able to develop two families of flash memories—one optimized for 5-V-only operation and a second for 3 V.

At odds with Atmel's approach, Intel and the many other companies that make single-transistor NOR cells also have been able to achieve high densities. However, they've made those gains by employing very-fine-line processes—0.6-μm-minimum features—to fabricate 16-Mbit memories. As a trade-off to keep the chip area within cost constraints, no bias supply was placed on the chip, necessitating an external 12-V programming voltage.

The decision to keep the bias supply off the memory chip comes partly from the system implementations that the memory designers expect to see. For example, one major application of NOR-based flash chips is in memory cards that hold from 1 to 40 Mbytes. Including the bias generation on each chip would add unnecessary overhead. Instead, one simple off-chip circuit can be used by the entire array of memory chips to supply the V_{PP} signal to any card chip.

The move toward NOR-based 5-V only parts, though, is starting to build. Advanced Micro Devices already offers 4-Mbit flash memories that require just a 5-V supply for read or store operations. And, most recently, Intel released details of a forthcoming enhanced flash memory family (mentioned earlier on) that can operate with a variety of power and programming supplies.

The shift to the 3.3-V operating levels means that the memory designers must compensate for the lower supply voltage by adjusting the internal transistor threshold levels. However, by doing that, they create a 3.3-V-only version of the memory, which is something they're not ready to do since the market for 3.3-V components isn't yet universal. Typically, if the supply voltage is lowered without adjusting transistor thresholds, the memories will usually work, though much slower. For example, Atmel offers a 5-V family of flash devices with access times ranging from 70 to 250 ns, while the 3.3-V versions come with access times comparable with the slowest of the 5-V devices.

The highest-density offering from Intel (the 16-Mbit flash), for example, operates from either 3.3 or 5 V and accesses in just 70 ns for reads. By using dual 256-byte on-chip page buffers, the flash memory has a write transfer rate of 430 kbytes/s—almost quadruple that of Intel's 8-Mbit chip. Endurance over previous-generation flash chips also was improved ten-fold from 100,000 cycles on the 8-Mbit generation to 1 million cycles (assuming the use of load-leveling algorithms).

Some companies took the NOR-type cell structure and made it small-

THE ORIGINS OF FLASH

The term "flash" actually emerged from research done in the 1980s involving the older byte-alterable, electrically-erasable programmable read-only memories (EEPROMs), which permitted users to store or erase data a word at a time. One of the first improvements, most likely coming at the behest of military users, was the ability to bulk-erase (flash erase) all memory locations with a single signal.

This type of a parallel-erase feature was needed for security. Such security was essential when systems incorporated EEPROMs to store maps, attack plans, etc. The advantage of the parallel erase feature was that the memories could quickly be erased if any unauthorized person tried to open the enclosure containing the memories.

In addition to providing security, the flash-erase capability allows memory-chip designers to shrink the size of the chip's memory array, translating into smaller chips and lower prices. By eliminating all of the address decoding and wiring needed to route the individual erase signals to each cell, the memory cells can be squeezed closer together.

However, erasing the entire chip just to rewrite a few bytes of data causes premature wear-out of the locations containing data that doesn't change. To try and compensate, and provide a compromise between byte- and chip-level erasure, designers divided the memory array into large sub-blocks—4, 8, 16, etc. Each sub-block can be flash erased and then rewritten independently, minimizing the amount of wear-out on the other blocks.

Block erasure is just one of many features flash-memory manufacturers offer on their chips. For instance, erase-protection or lockout capability is included on another class of flash memory created by Intel. The boot-block flash is divided into multiple sub-blocks, but unlike the standard block-architecture flash memories, the block sizes in the boot-block memory aren't all the same. Rather, the number of words in each block are optimized for the function each block will play in the expected application—the BIOS and system support memory in desktop and portable computer systems.

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er. For example, researchers at Mitsubishi's laboratories came up with a scheme called DINOR, an advanced version of existing NOR-type cells. DINOR cells, which are smaller than previous NOR cells, can operate and be programmed with low voltages. As a result, a memory chip based on DINOR cells can operate from a single 5- or 3.3-V supply. This cell will be used in a 16-Mbit flash memory to be manufactured initially by Mitsubishi. It's targeted for applications that will otherwise execute from working-storage RAM.

Hitachi reached an agreement with Mitsubishi whereby the two companies will jointly develop a novel 64-Mbit flash memory that combines the NOR and NAND memory architectures to form an AND-type memory architecture. Furthermore, Hitachi will co-market the Mitsubishi 16-Mbit, NOR-based flash memory. The novel AND cell incorporates aspects of both the NAND and NOR structures and permits erasures in blocks as small as 512 bytes. The AND-type architecture is best suited, according to Hitachi, for applications like file-storage and disk-drive replacements.

The two companies, though, will eventually consolidate their 16- and 64-Mbit product lines so that they offer common specifications and, hopefully, get accepted as a de facto industry standard. In the meantime, Hitachi offers a 4-Mbit flash memory that's similar to Intel's base-architecture 4-Mbit offering, but employs a smaller sector size—just 16 kbytes.

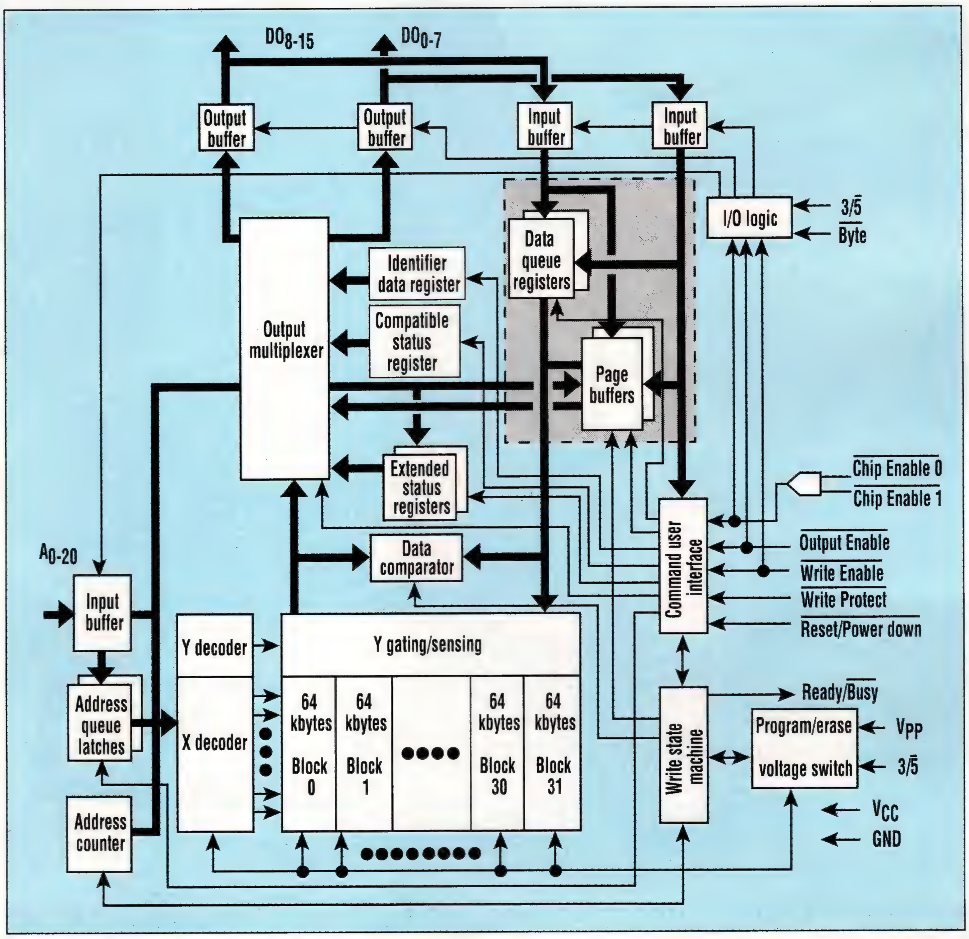
While flash-memory chip sizes and power-supply voltages are decreasing, their densities continue to climb. For example, researchers at NEC Corp., Tokyo, Japan, presented details earlier this year of a 3.3-V flash-memory chip with 64 Mbits of storage capacity. Described at this past February's International Solid-State Circuits Conference, the 4-Mword-by-16-bit memory can access data in just 50 ns. It contains an internal 256-bit buffer that holds up to 16 words during the store cycle.

Such a buffer is common to most high-density, electrically programmable memories because the storage cycle can require from 1 to 10 ms. To save time, most memories allow a number of bytes or words to be loaded at read-like speeds (70 to 250 ns/transfer) into a small on-chip buffer, and then store all of the data in parallel. That allows the store time to be "averaged" over all 16 words (in NEC's case), bringing the average store time per word to less than 1 µs. Without such an approach, the programming time to load the entire array would extend to minutes rather than a second or two.

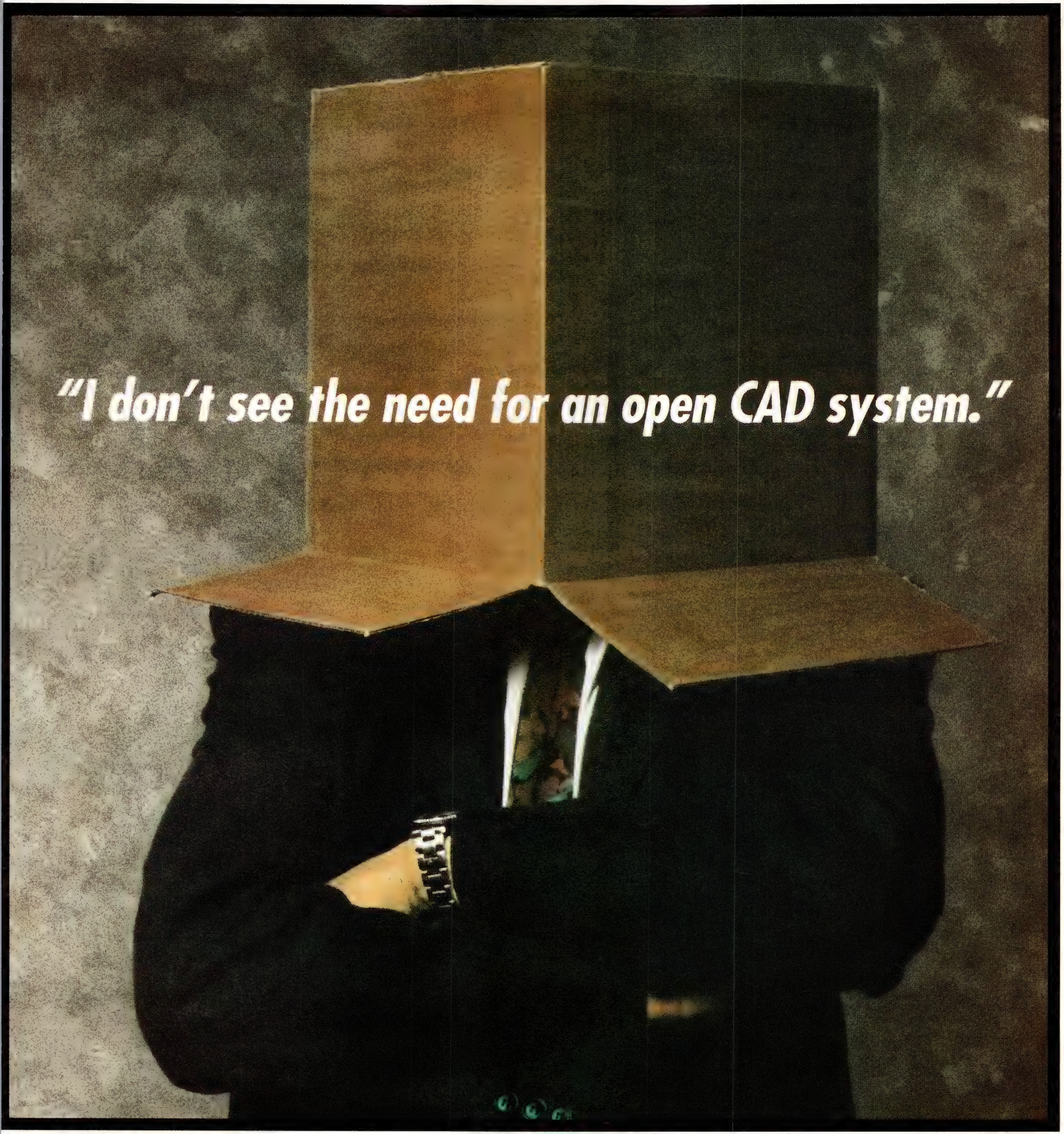
ABUNDANT FEATURES

For instance, in Intel's 28F016SA, a 16-Mbit NOR-based flash memory, two 256-byte page buffers boost sustained write throughput to 430 kbytes/s *(Fig. 2)*. The buffers are used in a ping-pong scheme. Data is written to one buffer, and while that buffer's contents are being stored in the flash cells, the second buffer can be loaded. When the first store operation is finished, the buffers switch functions and the second buffer's contents are stored, while the first buffer can be loaded with new data. By switching back and forth, the memory chip can continually store data, minimizing delays to the host.

Intel also made the operation easier by putting in many of the features mentioned early in this article: an instruction queue to pipeline operations, a microcode-driven state machine that allows store operations to be temporarily halted so a read operation can be performed, and a switchable organization (by-8 or by-16). The chip's 16-Mbit memory array is orga-



2. DUAL 256-BYTE PAGE REGISTERS in Intel's 16-Mbit flash memory make it possible for the chip to continually store data. It switches back and forth between the registers so that one fills up with new data while data from the other register is stored in the array.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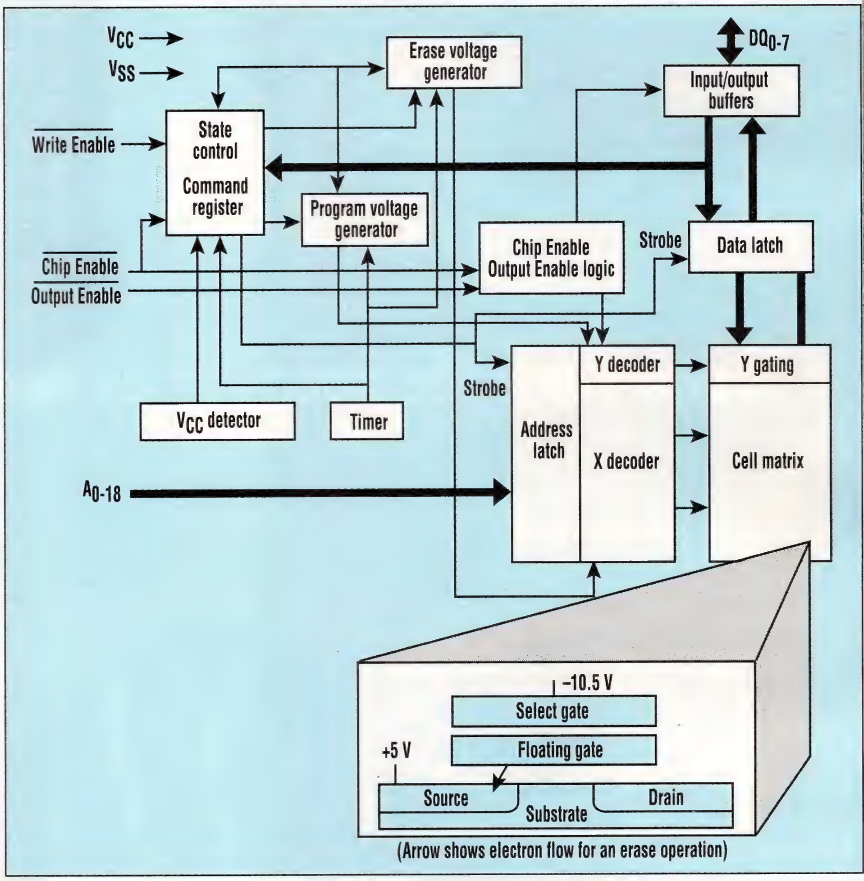
nized as 32 sub-blocks, each independently lockable to prevent overwrites.

Write instructions from the host controller are managed with an intelligent algorithm that levels the write-wear. As a result, the memory can endure 1 million store cycles to any 64-kbyte block on the chip. When active, the memory chip draws about 60 mA from a 5-V supply and about 35 mA when powered by a 3.3-V supply. On-chip power management automatically shifts the memory into a standby mode that drops current drain to between 1 and 2 mA. With some system-level power management, a deep power-down mode drops the current drain under 2 µA.

However, as mentioned earlier, the chip's designers did forsake the use of an on-chip voltage booster, which would have let the memory be programmed with just a 3.3- or 5-V external power supply. Consequently, a 12-V V_{PP} level must be applied to the chip to store data.

Following a similar approach, a 16-Mbit chip recently released by Mitsubishi gives designers a sub-block architecture that matches Intel's 16-Mbit chip. In addition, it has the erase-suspend capability, but is available only in a byte-wide configuration with 100,000 store cycles guaranteed. Through an alternate-sourcing agreement, SGS-Thomson Microelectronics also will manufacture an equivalent part.

Both Advanced Micro Devices and Atmel took a different route by developing second-generation flash memories that require just a 5-V supply for reads or stores. AMD's 29F040, a 4-Mbit device organized as 512 kwords by 8 bits, can access its data in 70 to 150 ns, depending on the speed-grade selected. The internal memory array is divided into eight equal-sized sectors of 64 kbytes each. Any combination of sectors can be erased concurrently, or all sectors can be erased to blank the entire chip. A write-suspend/resume capability also is included. Endurance for the memory cells is 100,000 cycles. Atmel's 1-Mbit flash uses small block sizes of 128 bytes each. This minimizes wear-out because fewer cells need reprogramming if just a few bytes have to be altered.



(Arrow shows electron flow for an erase operation)

3. THIS 4-MBIT, 5-V-ONLY FLASH MEMORY, developed by Advanced Micro Devices, employs a much simpler architecture than Intel's 16-Mbit chip. The on-chip programming-voltage generator simplifies the design of the host system by eliminating the need to provide a high-voltage signal for storing data. A biasing scheme called "negative gate erase" eases cell deprogramming by pulling the charge from the gate and pushing the electrons out with a negative bias voltage on the control gate (inset).

The flash-memory chip's internal architecture is much simpler than that of Intel's 16-Mbit device, but as the memory array gets larger, overhead issues promise to add complexity to ensure programming overheads don't bog down the system *(Fig. 3)*. Rather than use the traditional programming scheme for the nonvolatile cells, designers at AMD developed a proprietary negative-gate erase technology. The process basically results in the same potentials as in the standard EPROM-like programming effectively being applied to the memory cell. And, like the EPROM cells such as those used by Intel, Fowler-Nordheim tunneling is used to erase the contents.

Although currently available chips include some power-down capability, a new type of power-down will be incorporated through chip deselection on a forthcoming 16-Mbit part. The next-generation parts also will be available with switchable 8- or 16-bit-wide bus interfaces.

Another company entering the flash market—Catalyst Semiconductor—developed its own NOR-based memory architecture based on the single-transistor memory cell similar to that used by Intel. A 1-Mbit, 5-V/12-V part is available now, and both 2- and 4-Mbit versions will be released later this year. The company also is developing a family of flash devices that will be compatible with the single-voltage flash memories offered by Atmel. Samples of the 5-V 1-Mbit chip should be ready in the fourth quarter, which will soon be followed up by a 3 to 3.3-V version.

NOR-based memories are ideal for applications that require high-speed accesses, but help is needed if they're to be used in disk-emulation subsystems. Software that lets an

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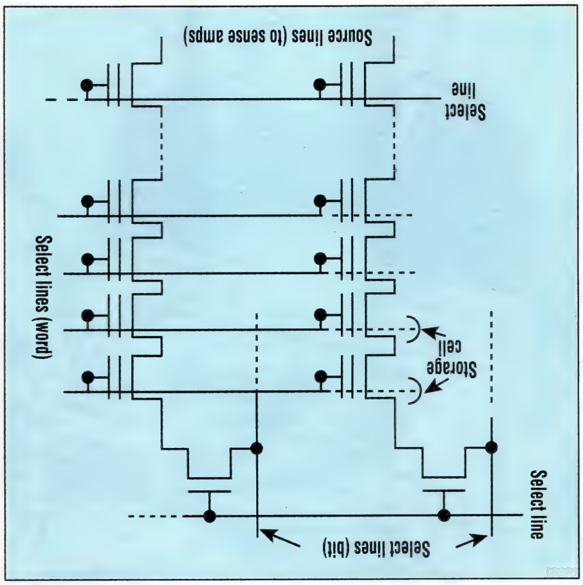
array of flash chips simulate the operation of a disk drive—a flash file system—can handle the file management. Some of that software also can be implemented as firmware in a control chip that manages the memories and read and write algorithms.

One such chip, jointly developed by Conner Peripherals Inc., San Jose, Calif. and Intel, provides all of the write-leveling to evenly distribute writes over the array of memory chips. In addition, the controller chip performs error detection and correction (EDC), and has other features that turn an array of flash chips into a solid-state disk drive.



4. IN THE NAND-BASED FLASH structure pioneered by Toshiba, multiple storage transistors are connected in series, just like transistors in a NAND gate. Such an arrangement saves considerable chip area compared with multiple NOR-type cells. That's because the source region of one transistor is merged into the drain region of the adjacent transistor, eliminating the need for a contact and allowing the transistors to be packed more tightly.

In its efforts to find high-volume vertical markets for flash memories, Intel's designers developed two chips that offer write-protection lockouts as part of the architecture. One of the two chips, the boot-block flash 28F001BX, contains 1 Mbit of storage, organized as 128 kwords by 8 bits. The 128 kwords are divided into sectors. However, unlike other sectored memories, the sectors on the 28F001BX are optimized for such applications as the BIOS storage in portable and desktop computers. In addition, Intel offers a 2-Mbit version and, later this year, will release a 4-Mbit version that also includes the recently unveiled SmartVoltage sensing scheme discussed earlier.

The sectors in the megabit part are organized as an 8-kbyte boot block, a pair of 4-kbyte parameter-block sectors, and a main block sector that holds 112 kbytes. The boot-block sector is protected (locked) through hardware and software interlocks which ensure that the contents of the 8-kbyte block can't be altered with normal TTL levels.

The use of flash memory to store the BIOS opens up new possibilities for system designers since system updates now can easily be done in the field either over a modem or by just downloading a new file. The catch, however, is that no user is comfortable wiping out the entire system memory before installing an "upgrade." To solve that problem, the boot-block memory can be configured so that several memory sectors are read-only and contain the basic programs to control machine operations.

For applications that store long contiguous fields, the file memory offers a different architectural approach by allowing higher-density, but more dedicated, flash chips to be tuned closer the system application. The file memory employs a structure that's optimized to access large serial strings of words. Thus, its access time is typically measured in microseconds rather than nanoseconds. However, as a replacement for electromechanical storage devices such as hard-disk drives, file memories can provide a 10- to 100-fold improvement in read-access time versus hard-disks. And, they deliver about the same performance when storing data in solid-state memory.

Most of the flash file memories are based on a NAND-type cell structure pioneered by Toshiba. The cell structure consists of a series-connected string of storage cells, much like the multi-input NAND-gate logic structure *(Fig. 4)*. By connecting multiple devices in series, the connection re-

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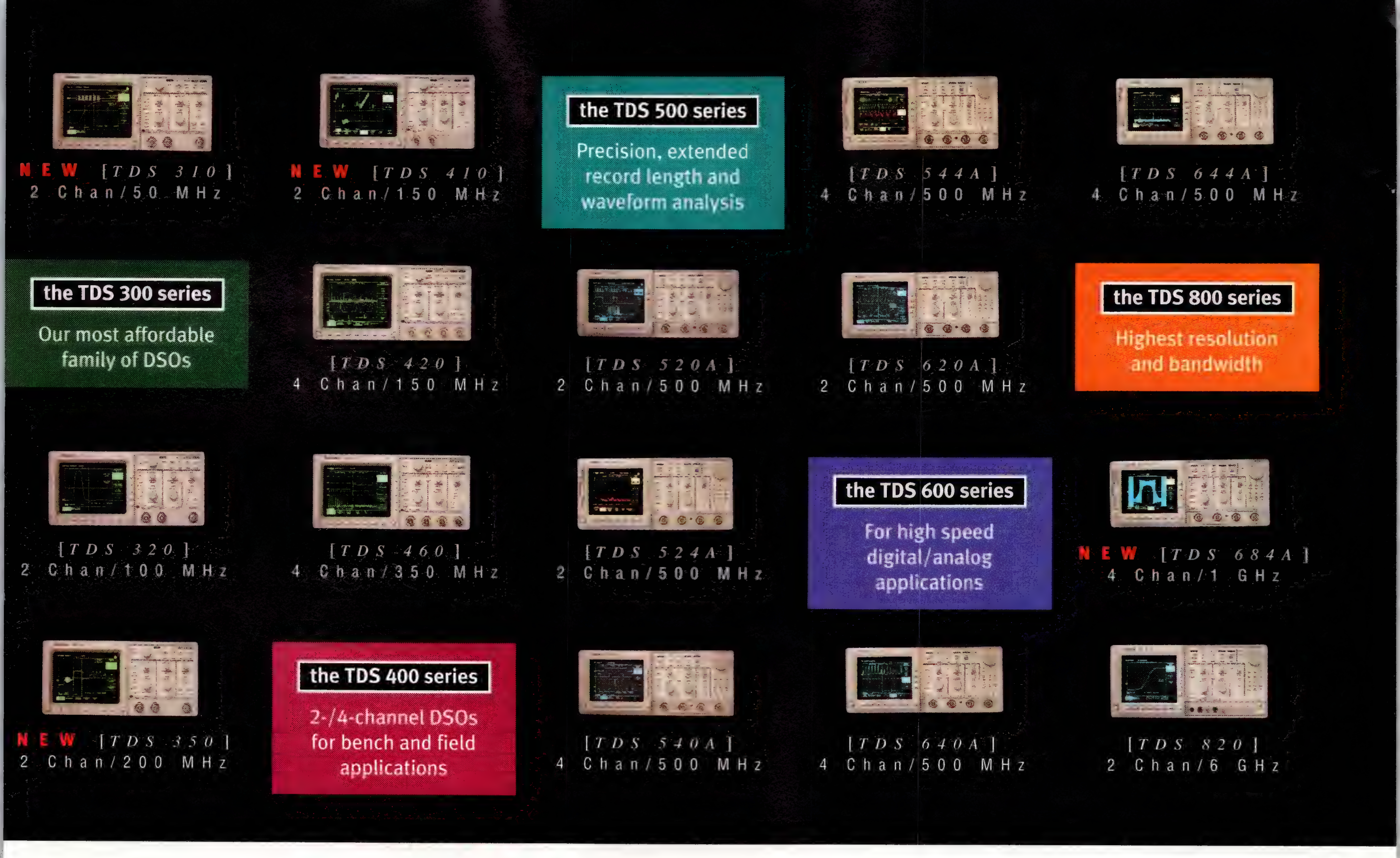
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gions between adjacent storage elements can be eliminated, reducing the space required for the transistors. The more-compact array allows chip designers to cram more bits on the chip and achieve higher densities than NOR-based memory arrays.

To further its flash-memory development, Toshiba struck a joint-development deal with National Semiconductor. Together, the two companies will develop 64-Mbit NAND-based file memories for high-density bit storage and configuration control, applications that don't require high-speed accesses. They also will combine their efforts to craft a family of NOR-based flash memories for applications that require high-speed random accesses. Until the 64-Mbit chip is ready, however, National and Toshiba will offer Toshiba's 16-Mbit, NAND-based flash memory as well as 1- and 4-Mbit byte-wide NOR-based flash memories.

To broaden the application base for flash memories, designers at National are working on a family of devices for the automotive industry. In addition, they're working with customers to define next-generation EEPROM functions. Automotive systems, which use a 12-V supply, have lots of available power, and can employ a different approach to take advantage of flash technology.

Catalyst also is trying to get into the memory-card disk-type storage market by developing a NAND-based flash-memory structure. To implement the controller circuit used in the solid-state drive, Catalyst formed a relationship with Zilog Inc., Campbell, Calif. Zilog will develop the controller and Catalyst the memory; the two will devise the memory-card architecture. First samples of the NAND-based chips should appear in the first quarter of 1995.

To ensure the integrity of the data held in the memory array, Samsung developed a 16-Mbit, NAND-based flash memory that includes EDC capability. It's expected that the same basic architecture can be extended at least to the 64-Mbit generation. Moreover, because the memory is targeted for file-storage applications, the 16-Mbit chip only contains 20 active pins, making it possible to squeeze the chip into a 44-lead thin, small-outline package. The number of active pins won't change as densities move to 64 Mbits.

In Samsung's KM29N16000, the chip's architecture allows a random access to reach any internal page in 15 ms, while serial accesses within a page take just 80 ns/byte. It takes about 290 ms to read all of the bits in the memory array, while programming the bits (at an average of 1.2 ms/byte) takes about 2.4 seconds. The flash erase that wipes the entire chip clean takes just 10 ms. To get that speed, the array is organized as 512 blocks of 16 pages (4096 bytes) each and an additional 128 bytes for various housekeeping and EDC functions (eight bytes per page). In the automatic page-program mode, the chip stores data into one page plus the accompanying 8-byte control block. The Auto Block-Erase command can wipe the contents clean in a 4096-byte block and its accompanying 128-byte control region. A Chip-Erase command blanks all 2 Mbytes of data space and the 64 kbytes of control space. A small processor that executes a simple command set controls all internal operations.

Also basing a family of flash memories on a small sector size, designers at Silicon Storage Technology defined 1- and 4-Mbit flash memories that are just now entering production. The chips will have a 128- and 256-byte block size, respectively, and employ the company's proprietary EEPROM-based hot-electron programming scheme that allows low-voltage operation and programming (5 or 3 V). The chip's manufacturing process will use about 30% fewer masking steps than most other flash processes. The split-gate design for the storage cell is about the same size as an EPROM memory cell.

The split-gate (two "effective" transistors) memory cell helps avoid the over-erase problem that can occur in single-gate cells. Moreover, using thick tunneling oxide minimizes potential problems due to material defects and endurance limitations. Both 16- and 64-Mbit versions are on the drawing boards. SST also is developing a controller chip that will manage the data storage to turn an array of the chips into a fault-tolerant solid-state drive.☐

THE DIFFERENCES BETWEEN NAND AND NOR FLASH MEMORIES

Probably one of the most bandied about aspects of flash-memory devices is the product differentiation between devices fabricated using either the NOR- or NAND-based memory cell. Although both types use floating-gate transistors for the storage elements, they differ in the way the memory cells are linked to other memory cells and/or the exact cell program and erase mechanism.

Based on equivalent feature sizes, chip-size estimates show that the NAND architecture produces chip areas equivalent to NOR-based chips, even when the architectures are extended to 64 Mbits. Thus, the actual size advantage of NAND-based chips is still open to debate.

Because NAND-based memories have longer initial access times, they're not as well suited for applications that require repetitive random accesses. Rather, the NAND approach appears to be most suitable in applications that sequentially store data, such as disk-drive replacements. However, even in the drive-replacement arena, the NAND-based products must compete with NOR-based subsystems. As a result, NAND-based products seem to be limited to only a fraction of the overall nonvolatile market, possibly to the point of being pushed out of the market by the sheer production volume of the more versatile NOR-based ICs.

Contributed by Kurt Wolf, technical marketing manager, Advanced Micro Devices Inc., Sunnyvale, Calif.

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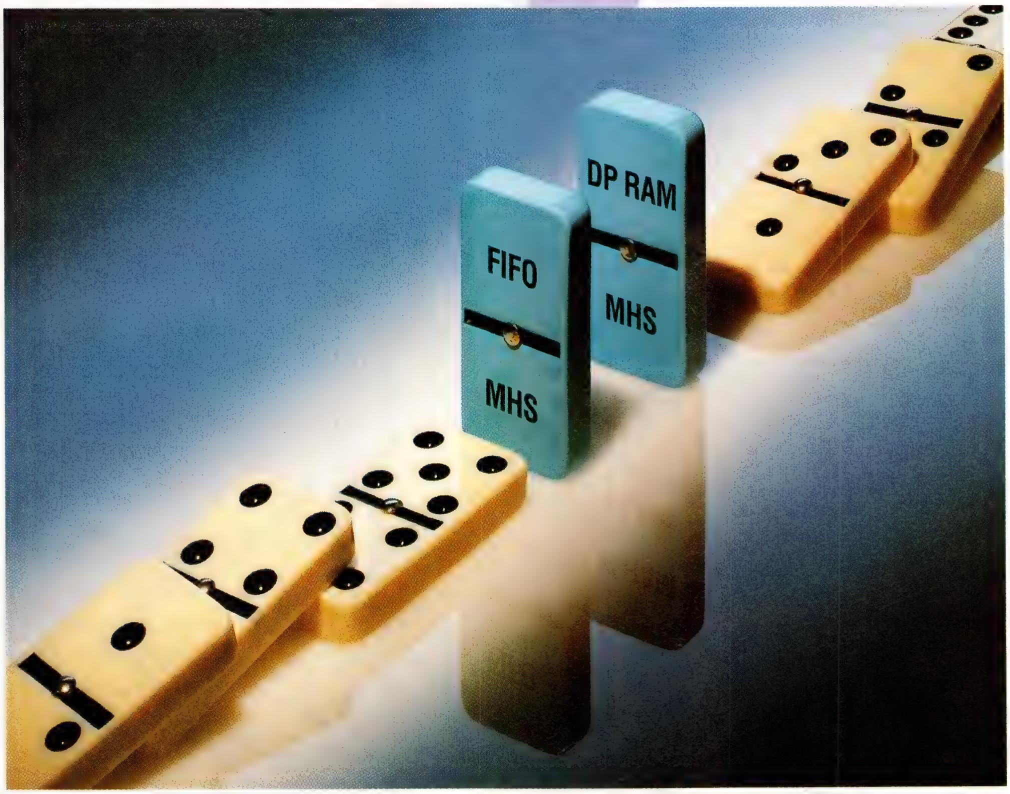

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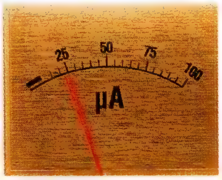

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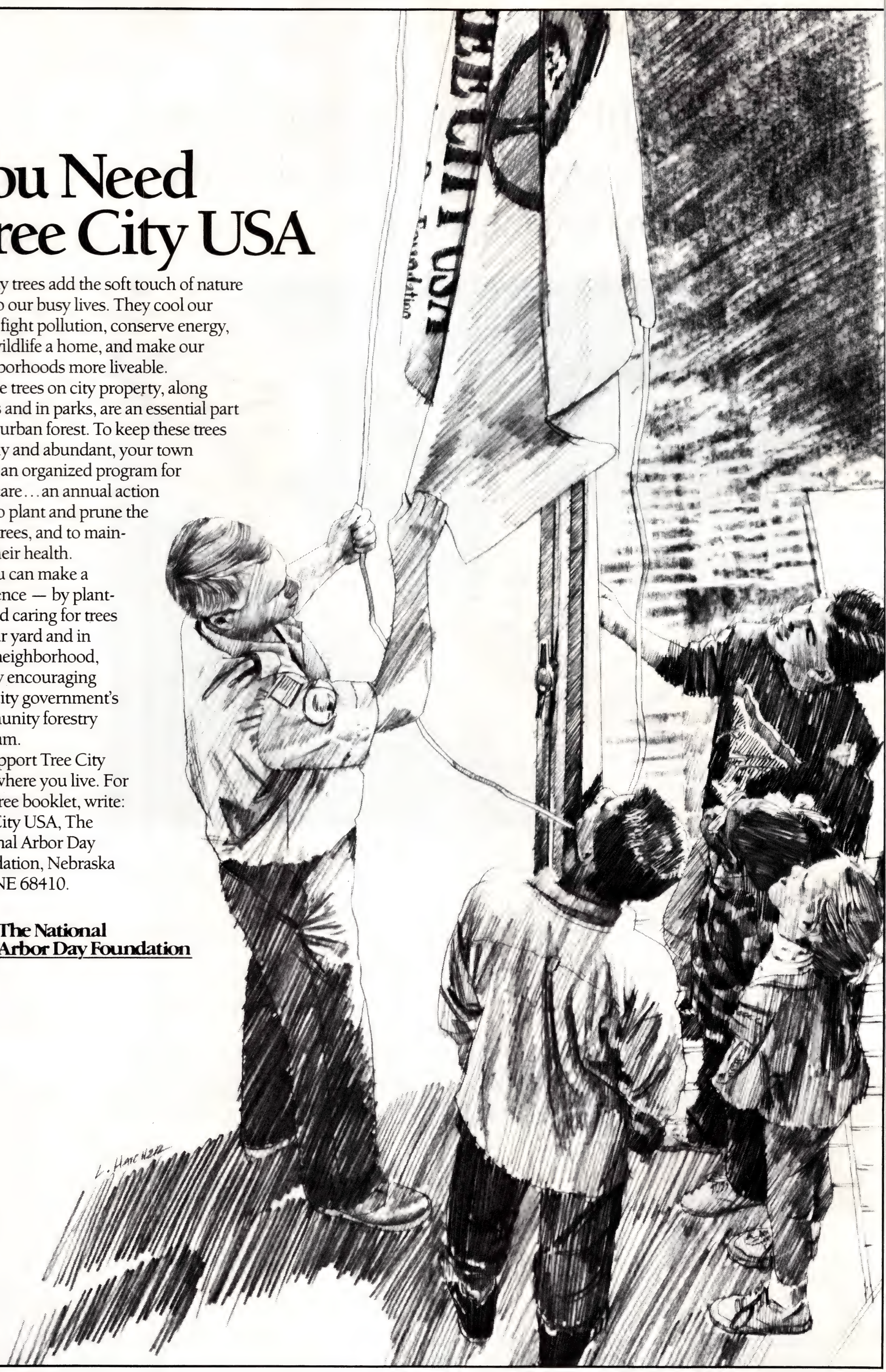

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TIPS FOR DESIGNING HIGH-GAIN AMPLIFIERS

TRANSISTOR MODELS, ENGINEERING APPROXIMATIONS, AND GAIN AND BANDWIDTH CALCULATIONS HELP SIMPLIFY AMPLIFIER DESIGN.

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Several techniques that emphasize intuition, not analytical results, can help simplify the design of a high-gain amplifier with wide bandwidth. This article takes a look these techniques, which include transistor models, gain and bandwidth calculations, and engineering approximations. The outcome is convincing—an augmented transistor model and a few back-of-the-envelope calculations yield surprisingly predictable results. Also presented here is a practical example and a discussion of design strategy.

Suppose you need to design a transistor amplifier with –1000 gain and a 1-MHz, –3-dB bandwidth. An op amp isn't available, and you want to do the design with as few components as possible. An amplifier circuit is submitted for your approval *(Fig. 1a)*. Will it do the job?

The small-signal network for this common-emitter amplifier is drawn using the standard transistor hybrid-π model *(Fig. 1b)*. The mid-band gain of this amplifier is:

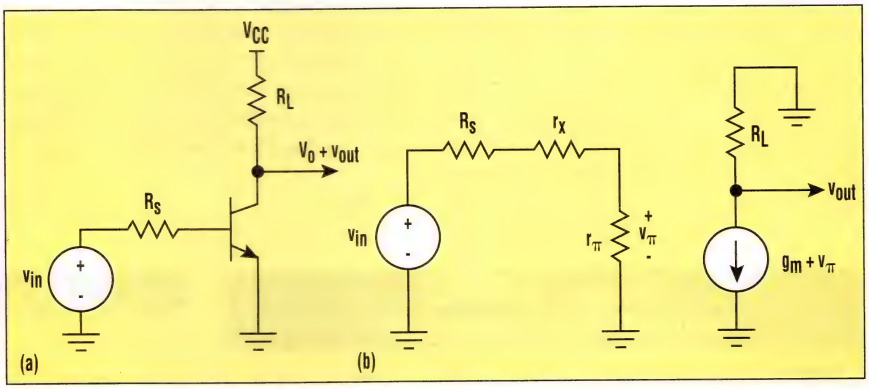
$$\frac{v_{out}}{v_{in}} = -g_m R_L \frac{r_\pi}{R_s + r_x + r_\pi} \qquad (1)$$

The gain of this amplifier approaches a theoretical maximum when R_s and r_x are small compared to r_π.

$$\frac{v_{out}}{v_{in}} \approx -g_m R_L \qquad (2)$$

Equation 2 calculates the maximum gain achievable with one resistively-loaded gain stage. From transistor theory, we know that the transconductance of a transistor is linearly proportional to collector current:

$$g_m = \frac{I_c}{V_{TH}} \qquad (3)$$



1. A RESISTIVELY-LOADED common-emitter amplifier is used as a high-gain circuit (a). The small-signal network for this common-emitter amplifier is drawn using the standard transistor hybrid-π model (b).

where the transistor thermal voltage $V_{TH} = kT/q \approx 25$ mV at room temperature. The small-signal gain is:

$$\frac{v_{out}}{v_{in}} \approx -\frac{I_C}{V_{TH}} R_L \tag{4}$$

For the transistor to stay biased in its linear region, the quiescent output voltage V_o must be higher than ground. The collector current of the transistor amplifier depends on power-supply voltage V_{CC} and quiescent output voltage:

$$I_C = \frac{V_{CC} - V_o}{R_L} \tag{5}$$

Finally, this gives a maximum theoretical gain of:

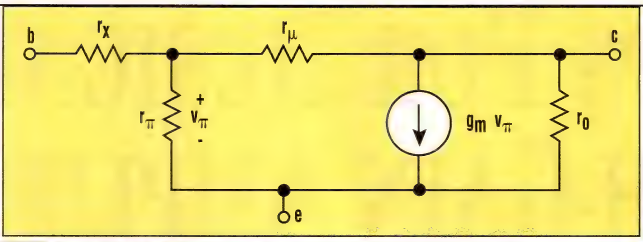
$$\frac{v_{out}}{v_{in}} \approx -\frac{(V_{CC} - V_o)}{V_{TH}} \tag{6}$$

For a supply voltage of 12 V and a small V_o, this transistor model shows that the small signal gain always will be less than 480. And if a reasonable output swing is desired, the gain will be significantly lower.

The simple hybrid-π model used for this analysis indicates that the voltage gain of a resistively-loaded amplifier may be increased to ∞ by increasing the power-supply voltage. Alternately, if the transistor is loaded with an ideal current source ($R_L = \infty$), the model shows that we can get infinite voltage gain. But common sense prevails and a more detailed look at the inner workings of the transistor reveals that infinite gain is impossible. We then must modify the hybrid-π model for high-gain circuits.

DETAILED MODEL

The simple hybrid-π model leads us to believe that transistor collector current doesn't change when collector voltage changes.[1] In other words, the simple model indicates infinite output impedance at a transistor's collector. Looking at an I_C versus V_{CE} trace on a transistor curve tracer dispels this notion. James Early was the first to describe this effect, called base-width modulation.[2].



2. MORE DETAIL is given to the simple hybrid-π transistor model by adding two more resistors to account for the effects of base-width modulation.

Base-width modulation causes both the collector current and base current of the transistor to change when the collector voltage changes. This also means that a transistor current source can't have infinite output impedance. The effect is modeled by adding two more resistors to the transistor model *(Fig. 2)*. This augmented low-frequency model should be used when analyzing circuits with gains in excess of a few hundred.

The g_m and r_π for the extended model are the same as before:

$$g_m \approx \frac{I_C}{V_{TH}} \tag{7}$$

$$r_\pi = \frac{h_{fe}}{g_m} \tag{8}$$

As a result of base-width modulation, the output resistance of the transistor (r_o) is inversely proportional to collector current.

$$r_o = \frac{1}{\eta g_m} \tag{9}$$

The proportionality constant η is what device physicists call the base-width modulation factor, which has typical values of 10^{-3} to 10^{-4}.

A change in collector voltage also affects base current. Changes in base current are a factor of h_{fe} smaller than changes in collector current. Therefore, the feedback resistance r_μ is:

$$r_\mu = h_{fe} r_o \tag{10}$$

The picture gets clearer b plugging some real number into the equations. Using curve tracer, the output resistance r_o and small-signa current gain h_{fe} of fou 2N3904 and 2N3906 transistors were measured (surel not a scientific sampling, bu who cares?). Other average parameters (r_π, g_m, r_μ) wer calculated *(Table 1)*. The averaged transistor-model values wi be used to design a high-gain transistor amplifier.

A DESIGN EXAMPLE

Consider the design of a one-gair stage amplifier *(Table 2)*. A commor emitter amplifier loaded with a current source will be designed using th measured transistor data *(Fig. 3a)*.

Q_1 is the common-emitter amplifie loaded with current-source transisto Q_2. The current source has a high output resistance, resulting in high gai from this one stage. The value of th input coupling capacitor is chosen C to meet the f_L specification.[3] Q_1 and Q are biased at approximately 2.5 mA.

Q_3 buffers the output, and Q_4 is V_{BE}-multiplier providing a voltag drop of approximately 8 V_{BE} so tha the feedback loop will bias the transistors properly. Ignoring the loading effects of $r_{\pi 1}$ on R_{in} and R_f, the amplifier's closed-loop gain is set by varying the potentiometer setting. Closed loop gain is approximately given by:

$$\frac{v_{out}}{v_{in}} \approx -\frac{R_f}{R_{in}} \tag{11}$$

This gain equation is exactly lik that of an inverting op-amp gai stage. In order for the amplifier t behave like an "ideal" amplifier, an for the gain equation to hold true, th amplifier's open-loop gain must b much larger than 1000. So, let's figur out the open-loop gain *(Fig. 3b)*.

Several approximations can b made when calculating open-loo gain. First, $r_\pi > R_{in}$, so the transistor'

TABLE 1: AVERAGE TRANSISTOR PARAMETERS

Transistor	I_c	r_π	g_m	r_o	h_{fe}	r_μ
2N3904	5 mA	1 kΩ	0.2 mho	75 kΩ	200	15 MΩ
2N3906	5 mA	875 Ω	0.2 mho	27 kΩ	175	4.7 MΩ

TABLE 2: DESIGN SPECIFICATIONS

Transistors	2N3904, 2N3906
Gain	> 1000
f_L (low-frequency –3-dB point)	< 500 Hz
f_H (high-frequency –3-dB point)	> 1 MHz
Power dissipation	< 100 mW
Power-supply voltages	+12, –12

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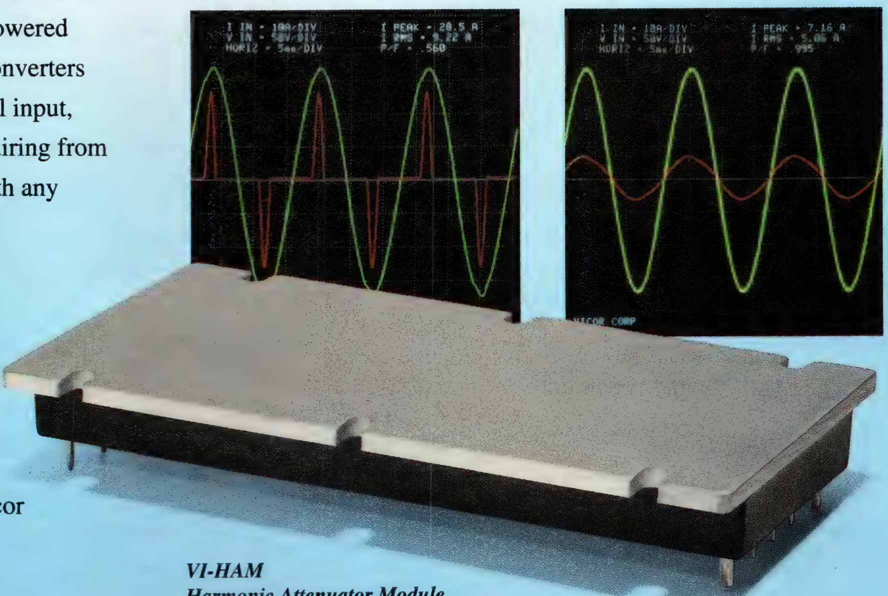

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TABLE 3: TRANSISTOR SMALL-SIGNAL PARAMETERS

Transistor	I_c	g_m	r_π	r_o	r_μ	C_π	C_μ
Q_1	2.5 mA	0.1	2 kΩ	150 kΩ	30 MΩ	50 pF	2 pF
Q_2	2.5 mA	0.1	1.75 kΩ	54 kΩ	9.4 MΩ	50 pF	4 pF
Q_3	1.5 mA	0.06	3.33 kΩ	250 kΩ	50 MΩ	30 pF	2 pF
Q_5	2.5 mA	0.1	2 kΩ	150 kΩ	30 MΩ	50 pF	3 pF

TABLE 4: TRY 1—CURRENT-SOURCE-LOADED COMMON-EMITTER AMPLIFIER

Parameter	Spice results	Prototype measurements
Closed-loop gain	1070	1050
f_L	180 Hz	190 Hz
f_H	220 kHz	400 kHz
Output swing	5 V p-p	5 V p-p
Power dissipation	70 mW	75 mW

input impedance won't load down the input that much. Second, the effective resistance due to feedback is R_f /(open-loop gain). This is also much smaller than R_{in}. The current-source transistor Q_2 is replaced by an equivalent resistance r_{out2} looking into the collector of Q_2. (We'll figure out real numbers later.) The emitter follower is replaced by an equivalent input resistance r_{in3} looking into the base of Q_3. Furthermore, the gain of the emitter follower will be close to 1, and won't be calculated here. The amplifier's open-loop gain is solved by summing currents at the output node:

$$g_{m1}v_{in} + \frac{v_{out}}{r_{o1}\|r_{out2}\|r_{in3}} + \frac{v_{out}-v_{in}}{r_{\mu1}} = 0 \qquad (12)$$

By grouping terms, and making the approximations:

$$g_{m1} >> \frac{1}{r_{\mu1}},\ r_{\mu1} >> r_{o1} \qquad (13)$$

we arrive at the final answer:

$$\frac{v_{out}}{v_{in}}(\text{open loop}) \approx -g_{m1}\{r_{o1}\|r_{out2}\|r_{in3}\} \qquad (14)$$

This is similar to the gain equation for the resistively-loaded common-emitter amplifier, except that in this case the load resistance at the output node has been made quite large by using a current source. Also, we can't ignore the input impedance of the emitter follower and the output resistance of Q_1. Going by the data in Table 1, we know that r_{o1} for Q_1 is approximately 150 kΩ, because r_o is inversely proportional to collector current, and Q_1 is biased at 2.5 mA. We still need to calculate the output resistance of the Q_2 current source r_{out2}, and the input resistance r_{in3} of the Q_3 emitter follower.

Q_1 and Q_2 are biased at 2.5 mA, with Q_3 biased at approximately 1.5 mA. The f_T for the 2N3904 and 2N3906 transistors is about 300 MHz. Each transistor has a base-spreading resistance $r_x \approx 150\ \Omega$ at this bias level. The C_π of each transistor is calculated by:

$$C_\pi \approx \frac{g_m}{2\pi f_T} - C_\mu \qquad (15)$$

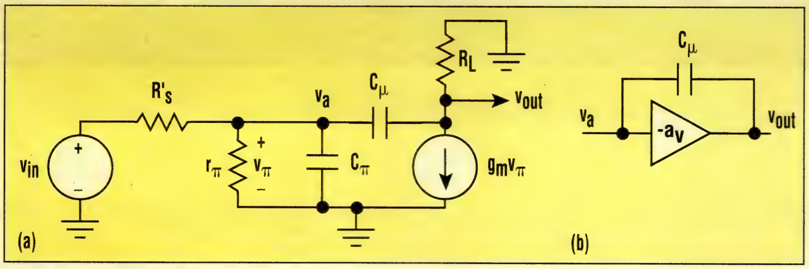
C_μ for each transistor is a few picofarads, and depends somewhat on the collector-base voltage. Small-signal parameters can be calculated for these bias levels *(Table 3)*.

We'll use a small-signal model to

THE MILLER APPROXIMATION

The Miller approximation is a useful way to think about high-gain amplifiers. For the common-emitter amplifier, consider the small-signal model *(see the figure, a)*. The amplifier is driven by a voltage source with source resistance R'_s, which may include the base-spreading resistance r_x of the transistor. Capacitance at node v_a may be modeled as C_π in parallel with some other elements. Then, the mid-band gain is:

$$\frac{v_{out}}{v_a} \approx -g_mR_L \qquad (B1)$$



The feedback around C_μ can be modeled with $a_v = g_mR_L$ as the gain from base to collector *(see the figure, b)*. The capacitance looking to the right of C_π is the so-called Miller capacitance. Miller capacitance is found by applying a test-voltage source to the v_a node, and finding the test current.

$$C_M = (1+a_v)C_\mu \qquad (B2)$$

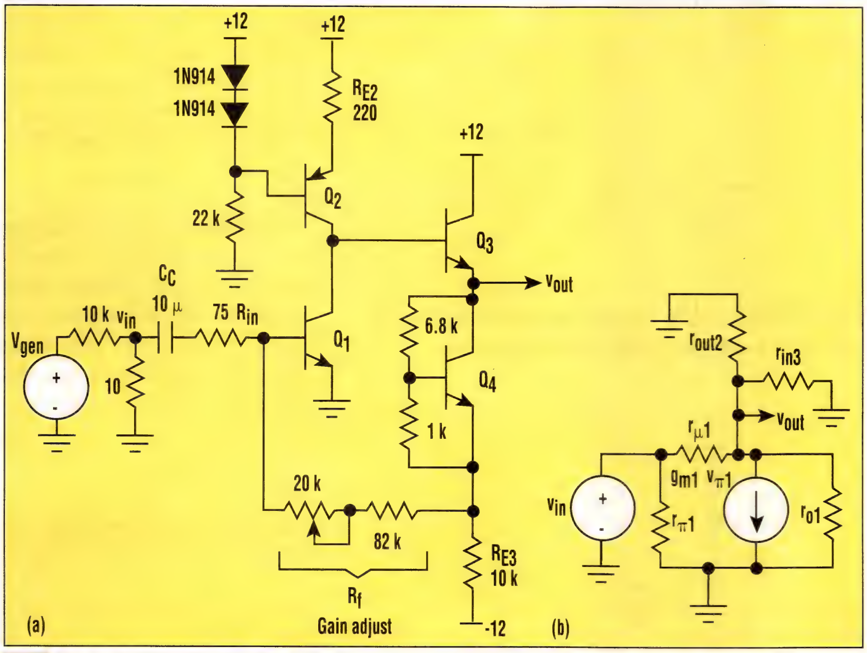
Total capacitance at node v_a is the sum of the Miller capacitance C_M with the intrinsic transistor capacitance C_π:

$$C_{in} \approx C_\pi + (1+a_v)C_\mu \qquad (B3)$$

For a high-gain amplifier (g_mR_L is large), the input capacitance is often dominated by the Miller capacitance, which is proportional to amplifier gain. In this high-gain case, the bandwidth of the amplifier is approximately given by the following equation:

$$\omega_h \approx \frac{1}{(R'_s\|r_\pi)C_{in}} \qquad (B4)$$

An exact analysis shows that the Miller-effect approximation is equivalent to calculating the dominant pole of the amplifier and ignoring other poles. In many cases, amplifier poles are widely spaced with one dominant pole, so it turns out that the approximation is a very good one.



3. A ONE-GAIN-STAGE common-emitter amplifier loaded with a current source is designed using the measured transistor data (a). The amplifier's open-loop gain is calculated from the circuit's small-signal model (b).

find the output resistance of the current source Q_2 *(Fig. 4a)*. A simplifying approximation is to ignore r_{x2} (which is small compared to $r_{\pi2}$) and the resistance of the diode string that's biasing Q_2's base (which is also small). To find this output resistance, add a test-voltage source V_T, and calculate the resulting current I_T.

At first, this circuit looks complicated, but it can be simplified to ease the calculation. It's clear from Figure 4 that the resistance at the collector of Q_2 is $r_{\mu2}$ in parallel with a bunch of other elements. Let's omit $r_{\mu2}$ and add it in later. We'll first find the output resistance of the modified circuit *(Fig. 4b)*.

Because the entire test current flows through the r_π-R_{E2} combination, the voltage $v_{\pi2}$ is found by:

$$v_{\pi2} = -I_T(r_{\pi2} \| R_{E2}) \tag{16}$$

where R_{E2} is the 220-Ω resistor at the emitter of Q_2. Solving for the test current:

$$I_T = \frac{V_T + v_{\pi2}}{r_{o2}} + g_{m2}v_{\pi2} = \frac{V_T - I_T(r_{\pi2} \| R_{E2})}{r_{o2}} - g_{m2}I_T(r_{\pi2} \| R_{E2}) \tag{17}$$

Recognizing that $g_{m2} > 1/r_{o2}$, this reduces to:

$$I_T\{1 + g_{m2}(r_{\pi2} \| R_{E2})\} \approx \frac{V_T}{r_o} \tag{18}$$

Now, adding in the $r_{\mu2}$, which we previously omitted, results in:

$$r_{out2} \approx r_{\mu2} \| r_o\{1 + g_{m2}(r_{\pi2} \| R_{E2})\} \tag{19}$$

TABLE 5: TRY 2—CURRENT-SOURCE-LOADED COMMON-EMITTER AMPLIFIER (WITH CASCODE)

Parameter	Spice results	Prototype measurements
Gain	1110	1100
f_L	180 Hz	190 Hz
f_H	1.1 MHz	1.3 MHz

The output resistance of the current source is made larger if there's an emitter resistor. Therefore, the 220-Ω resistor in our circuit helps to increase the current source output resistance. If $R_E > r_\pi$, the output resistance approaches $r_\mu/2$, which is a very large value. At the bias levels chosen, component values are $g_{m2} = 0.1$, $r_{\pi2} = 1750$ Ω, $r_{o2} = 54$ kΩ, and $r_{\mu2} = 9.4$ MΩ. The output resistance $r_{out2} \approx 900$ kΩ.

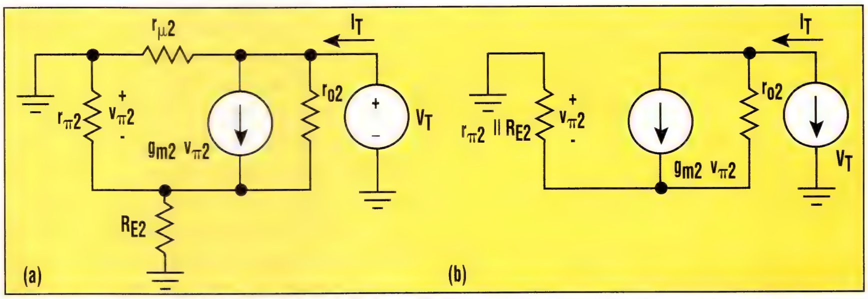
The final step is to find the input resistance of the emitter follower *(Fig. 5)*. The resistance looking into the base of Q_3 (the derivation of which is left as an exercise for the reader) is given by:

$$r_{in3} = r_{\mu3} \| \{r_{\pi3} + (1 + h_{fe3})(r_{o3} \| R_{E3})\} \tag{20}$$

With $R_{E3} = 10$ kΩ, Q_3 is biased at approximately 1.5 mA, resulting in: $g_{m3} = 0.06$, $r_{\pi3} = 3.3$ kΩ, $r_{o3} = 250$ kΩ, and $r_{\mu3} = 50$ MΩ. This results in $r_{in3} \approx 2$ MΩ.

Because r_{o1} is the smallest of the three resistors at the output node, it's the limiting factor in the amplifier's open-loop gain. The sum of the three equivalent resistors in parallel results in a resistance of approximately 114 kΩ between the high-gain node and ground. From Equation 14, the open-loop gain is approximately -11,400. This gain is high enough so that when the loop is closed, the amplifier's gain should approach the ideal gain.

If the gain is now acceptable, what about the bandwidth? If we assume that there's one dominant pole (that pole being due to the Miller capacitance of Q_1), and that all other poles are at frequencies much higher than 1 MHz, the gain-bandwidth product of the amplifier will be constant. In order for our amplifier with closed-loop gain

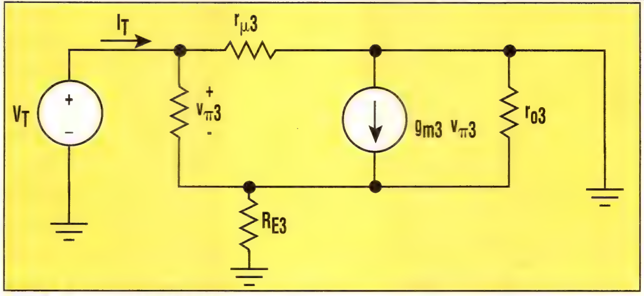


4. THE SMALL-SIGNAL MODEL of the current source Q_2 is used to find its output resistance (a). At first this circuit looks complicated, but it's possible to simplify it by omitting $r_{\mu2}$ (b).

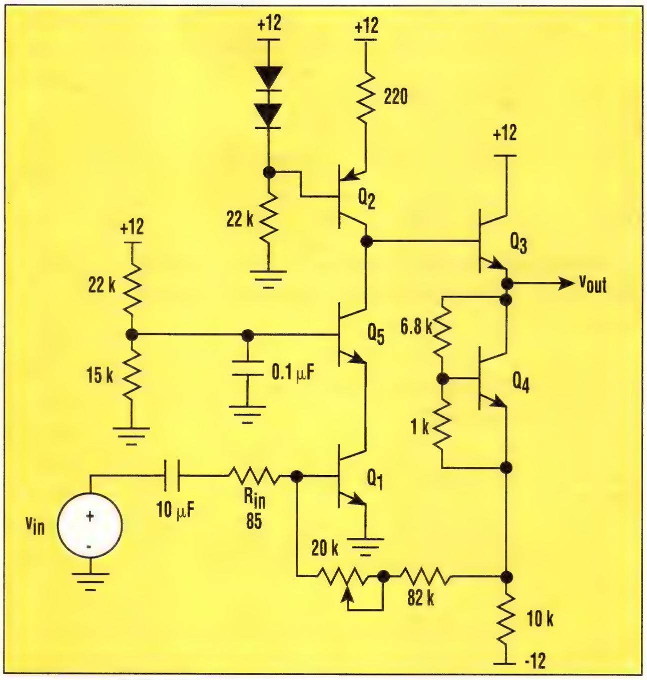
of –1000 to have a –3-dB bandwidth of 1 MHz, the open-loop bandwidth must be at least 90 kHz (at a gain of 11,400). The dominant pole of this amplifier is due to the effective source resistance ($R_{in} + r_{x1}$) interacting with the Miller capacitance *(see "The Miller approximation," p. 86)*. Other poles (for instance, in the emitter follower Q_3) will be at much higher frequencies. This can be seen by applying the method of Open-Circuit Time Constants to the amplifier.[4,5] Using the Miller approximation, and assuming $a_v = 11{,}400$, $C_{\mu 1} = 2$ pF, $r_{\pi 1} = 2$ kΩ, $r_{x1} = 150$ Ω, and $R_{in} = 85$ Ω, the open-loop –3-dB bandwidth is given by:

$$f_H \approx \frac{1}{2\pi\{(R_{in} + r_{x1})\|r_{\pi 1}\}a_v C_{\mu 1}} \approx 33\text{ kHz} \qquad (21)$$

The Miller approximation tells us that at a gain of 1000, the closed loop bandwidth won't be much larger than 380 kHz. Measurements on the breadboard prototype and Spice results confirm this prognosis *(Table 4)*. The Miller effect is killing us!



5. ENGINEERS CAN calculate the input resistance of the emitter follower using the circuit's small-signal model.



6. ADDING A CASCODE transistor will eradicate the Miller effect and squeeze more bandwidth out of the single-stage high-gain amplifier circuit.

What can be done to squeeze more bandwidth out of the circuit? Because the Miller effect is hurting us, let's overcome it by using a cascode transistor *(Fig. 6)*. With the added cascode transistor Q_5, the gain at the collector of Q_1 is low because transistor Q_5 has a small output resistance at its emitter. This defeats the Miller effect by isolating the high gain node from the input transistor Q_1. The input capacitance of Q_1 is now much lower (approximately $C_{\pi 1} + 2C_{\mu 1}$), moving the input pole up to a frequency given by:

$$f_{input\_pole} \approx \frac{1}{2\pi\{r_{\pi 1}\|(R_{in} + r_{x1})\}(C_{\pi 1} + 2C_{\mu 1})} \approx 14\text{ MHz} \qquad (22)$$

This amplifier's dominant time constant will be the resistance of the high-gain node (now higher than 114 kΩ, due to the cascode transistor) interacting with the various capacitances at the node. All other poles will be at frequencies much higher than our closed-loop bandwidth of 1 MHz. The modified circuit also will have a higher open-loop gain, because the cascode transistor reduces the effects of base-width modulation on transistor Q_1.

Now, let's do a non-rigorous, seat-of-the-pants calculation. Because Q_5 has a high impedance at its emitter, the output resistance at the collector of the cascode transistor will be approximately $r_{\mu 5}/2$ *(see Equation 18)*. Consequently, the equivalent resistance r_{eq} at the high-gain node now is approximately equal to the output resistance of the current source r_{out2} in parallel with the input resistance of the emitter follower. This resistance $r_{eq} \approx 600$ kΩ. Therefore, the open-loop gain ($\approx -g_{m1}r_{eq}$) $\approx -60{,}000$.

$C_{\mu 2}$ will be slightly larger than in the previous circuit, because V_{CB2} is smaller with the added cascode transistor. There's no Miller effect, so the total capacitance C_T at the high-gain node is approximately $C_T = C_{\mu 5} + C_{\mu 2} + C_{\mu 3}$ + stray capacitances ≈ 10 pF. Given this, the dominant open-loop pole is approximately:

$$f_{OL} \approx \frac{1}{2\pi\, r_{eq} C_T} \approx 26\text{ kHz} \qquad (23)$$

The poles are widely spaced, so the feedback loop should be stable and with a bandwidth 60 times larger than the dominant open-loop pole ≈ 1.6 MHz. We expect the actual bandwidth to be lower, and measurements show that it is, due to other unexplained effects *(Table 5)*.

Finally, the bandwidth specifications have been met. This article demonstrates that it's possible to design a simple, high-gain amplifier with wide bandwidth. To reiterate, the approach used was designed to emphasize intuition, not analytical results. ☐

Marc Thompson is a senior engineer at Polaroid's Medical Imaging Systems, where he specializes in high-speed analog design. He has two patents for the design of high-speed, high-power laser diode modulators. Marc holds a BSEE and MSEE from the Massachusetts Institute of Technology, Cambridge, and is currently on a leave-of-absence from Polaroid pursuing his PhD at MIT.

This article is fourth in a series of Marc's analog design articles that have run in Electronic Design over the past year. The four articles are based on his analog-design seminar that's offered at Polaroid.

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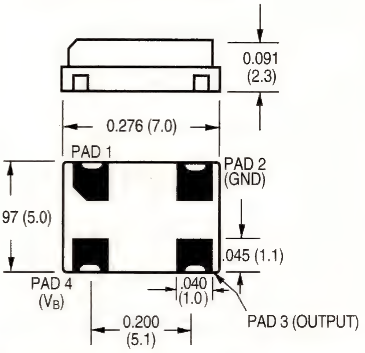

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T1258	Fixed	.01%	-40 to +85°C	5V ± 0.5V
T3290	Tristate	.01%	0 to 70°C	5V ± 0.5V
T3292	Tristate	.005%	0 to 70°C	5V ± 0.5V
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John Wiley and Sons: New York, 1975, p. 309-326.

2. Early, James, "Effects of Space-Charge Layer Widening in Junction Transistors," Proceedings of the I.R.E., November 1952, p. 1401-1406.

3. Thompson, Marc, "SCTC Analysis Estimates Low-Frequency –3-dB Point," *Electronic Design*, October 1, 1993, p. 65-68.

4. Thompson, Marc, "Design Linear Circuits Using OCTC Calculations," *Electronic Design Special Analog Issue*, June 24, 1993, p. 41-47.

5. Thompson, Marc, "Network Tricks Aid in OCTC," *Electronic Design*, December 16, 1993, p. 67-70.

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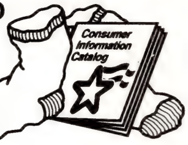

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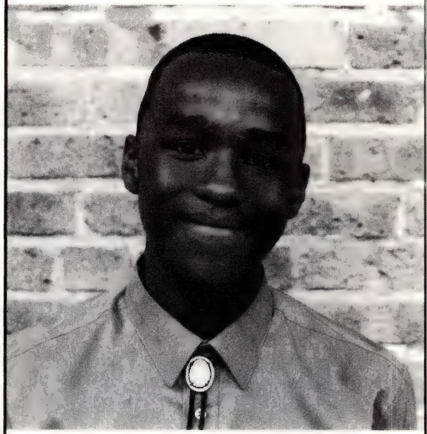

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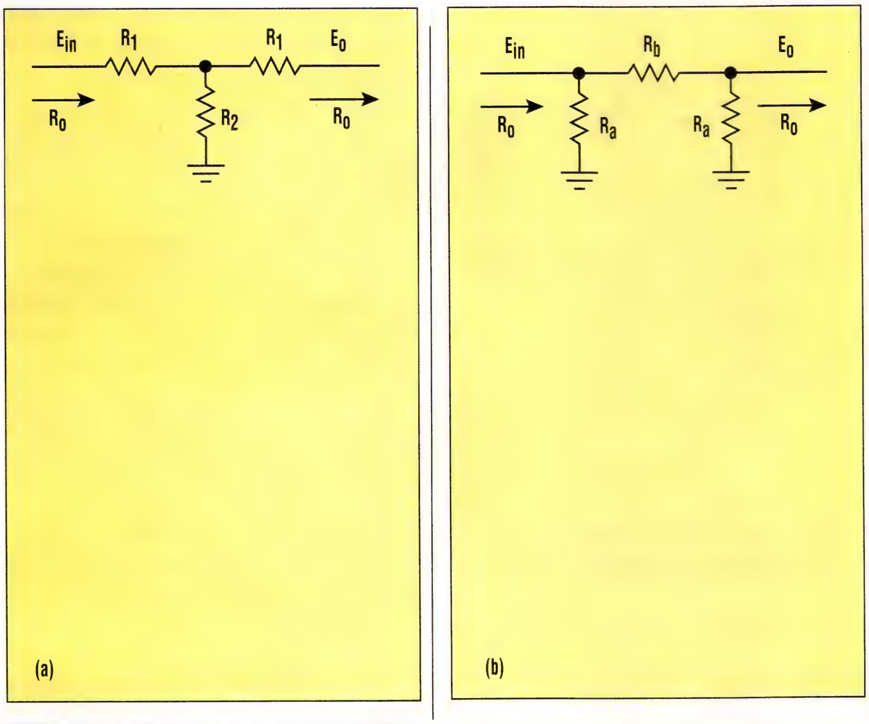
CIRCLE 521

ATTENUATOR DESIGN EQUATIONS

PATRICK H. CONWAY
28361 Plainfield Dr., Rancho Palos Verdes, CA 90274.



EQUATIONS ARE PROVIDED for the resistor values of symmetrical "T" and "π" attenuators at an impedance level of R_0 Ω as a function of voltage gain A, as well as equations for transformation between the two types.

Deriving equations to find component values for a given network can be quite a tedious task for engineers who have been away from school for several years. Textbooks or handbooks usually don't include such equations. One particular book, the SAMS-ITT *Reference Data for Radio Engineers* (6th edition), does include some helpful tables, but they're not general enough.

In the figure, equations are given for the resistor values of symmetrical "T" and "π" attenuators at an impedance level of R_o Ω as a function of voltage gain A ($A = E_o/E_{in}$ for $0 < A < 1$). Expressions for the ratios of the resistor values are also given, because they can be useful in finding one resistor value as a function of the other. Equations for network attenuation and "T" to "π" transformation equations also are given.☐

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S.R. Kaul, I.K. Kaul, and R. Koul, Bhabha Atomic Research Centre, Nuclear Research Laboratory, Trombay, Bombay, India 400 085. Their idea: *"Generate Varying-Width Pulse Groups."*

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Electronic Design, 611 Route 46 West, Hasbrouck Heights, N.J. 07604. Telephone: 201-393-6070; Fax: 201-393-0204

CIRCLE 522

ENHANCED VARLEY LOOP LOCATES FAULTS

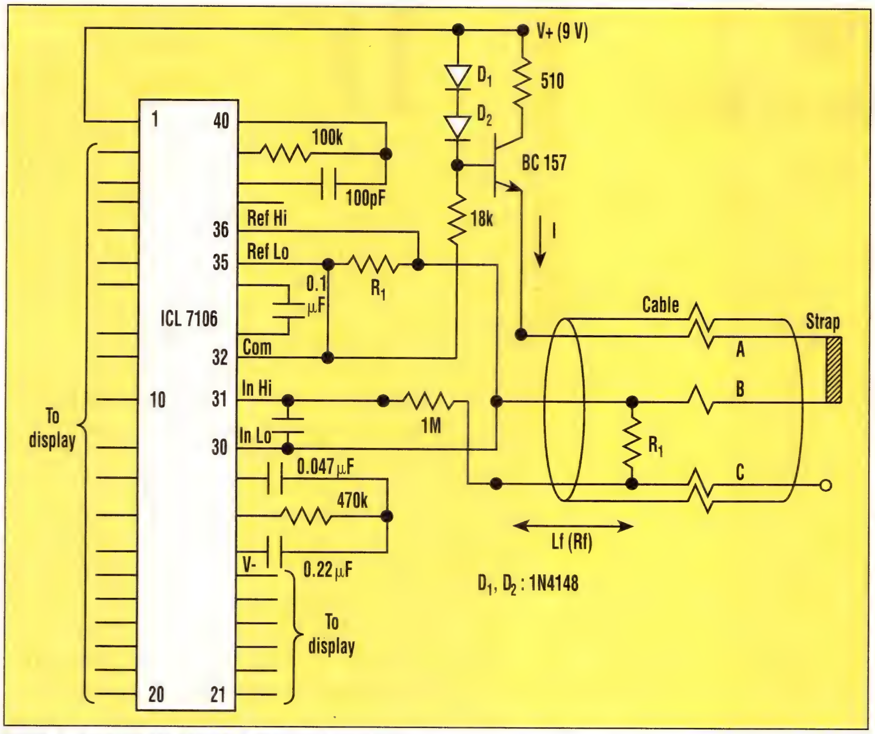
DEVADOSS JOHN and K.R.S. SARMA
Hindustan Cables Ltd., Industrial Development Area, Cherlapalli, P.O.
Hindustan Cables Hyderabad-500 051, Andhra Pradesh, India.

Using the Varley-loop configuration to localize insulation faults in multipaired pulp-insulated cables has been practiced for quite some time. The standard configurations require precision potentiometers for manual nulling and calibration.

However, modifying the Varley loop, and including a 3.5-digit digital panel meter chip (ICL 7106), eliminates the need for bridge balancing *(see the figure)*. As a result, it will directly display the wire resistance or distance to the insulation fault accurately.

Looking at the circuit, B and C represent two wires of a faulty pair in a multipair telecommunications cable. A fault in the insulation, of resistance R_i, lies at a distance of L_f from the near end. The corresponding conductor resistance to the fault is R_f. At the far end, conductor B is strapped to a good wire (A), which may be available within the cable.

The constant-current source drives approximately 1.2 mA



A MODIFIED VARLEY-LOOP configuration, along with a 3.5-digit dpm chip, eliminates the need for bridge balancing when trying to localize low-insulation faults in multipaired, pulp-insulated cables.

through the wires A and B and the reference resistance (R_r). The voltage across R_f is applied to In Hi and In Lo via the insulation fault resistance (R_i). The voltage across R_r is applied to the inputs Ref Hi and Ref Lo. The number displayed by the dpm is equal to $(R_f/R_r) \times 1000$. By properly selecting R_r, R_f or L_f can be displayed directly.

When $R_r = 100\ \Omega$, R_f is measured in the 0-to-199.9-Ω range. L_f is displayed directly in meters by suitable choice of R_r, taking into account the wire gauge, temperature, and the temperature coefficient of the conductor's resistance. For example, L_f is measured in the 0-to-1999-meter range when $R_r = 86.0\ \Omega$ for a copper conductor of 0.51 mm in diameter at 20°C.

The circuit is particularly useful in cable factories where accuracies better than ±0.2% are required for R_i less than 0.5 MΩ. For field use, it must be modified to include additional ranges and compensation for externally induced potentials.☐

CIRCLE

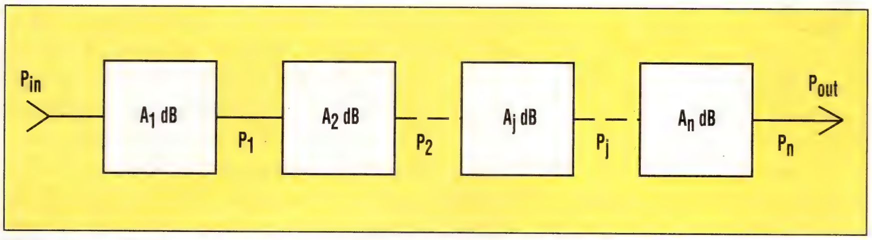
523

EQUALIZE PAD POWER DISSIPATIONS

JOHN DUNN
181 Marion Ave., Merrick, NY 11566.

When an RF or microwave signal of excessively high power must be attenuated, one option is to use several cascaded pads. For example, an attenuation of 33 dB could come from a combination of 3 dB and 30 dB. But if the excessive power is really high, attention must be paid to the relative power dissipations of the two pads. In this case, the 3-dB pad would be put in first followed by the 30-dB pad, thus roughly equalizing the power dissipation burden placed on each.

The program given *(see the listing)* finds what decibel values would be used for equal pad power dissipations in cascades of two to six pads, given the pad cascade's total attenuation. Three hypothetical examples are given to help illustrate. For each total attenuation, those pads which sum to that total are shown along with the fraction of the total input power each pad would absorb. In one case, a total of 10 dB using four pads could be achieved with 1.11, 1.49, 2.28, and 5.12 dB, with each dissipating 0.225 times the total input power. Where odd values of attenuation are called for, the values can serve as a selection guide. In the aforementioned example, 1 dB, 1.5 dB, 2.5 dB, and 5 dB could be used to achieve a reasonable power dissipation balance.



EQUALIZING THE POWER DISSIPATION for each attenuator pad (A_1 through A_n) and finding the number of pads that are required can be calculated with the program shown.

Next, the user is asked how many decibels of attenuation are needed and with how many pads that attenuation requires to be obtained. Upon entry, the results are presented similarly to the examples *(see the figure)*.

Let P_d be the power dissipated in each attenuator pad (A_1 through A_n), where there are n such pads in cascade. Total attenuation is A dB. Therefore, with each attenuator dissipating P_d:

$$P_d = (P_{in} - P_{out})/n$$

The power level at the output of each attenuator A_j is called P_j. At the output of the jth attenuator is:

$$P_j = P - j(P_d/n)$$

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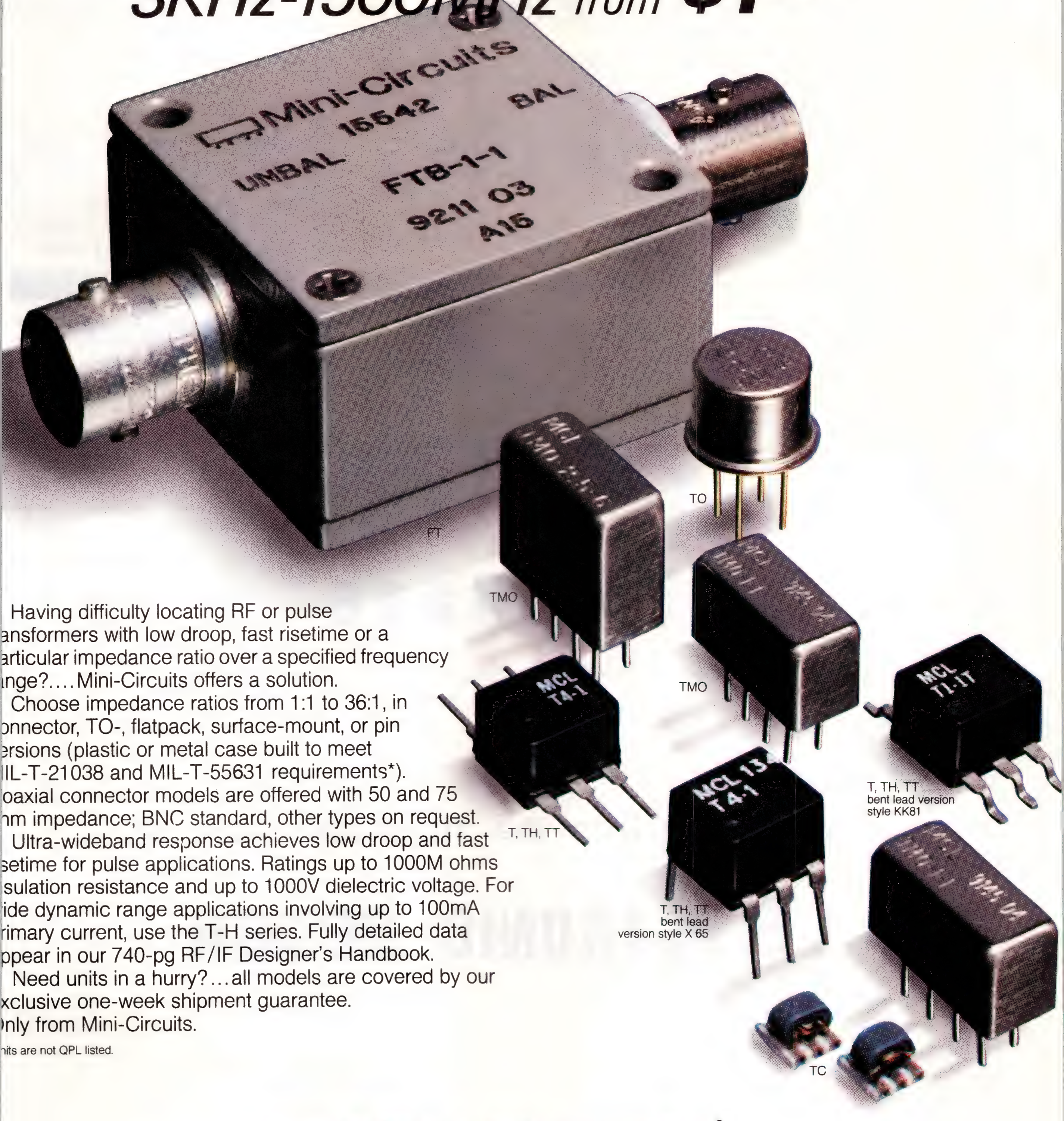

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```
10 CLS:SCREEN 9:COLOR 15,1:DIM A(10),P(10),A$(10),B$(10),PL(10)
20 PRINT "save "+CHR$(34)+"equipads.bas"+CHR$(34):PRINT
30 PRINT "save "+CHR$(34)+"a:equipads.bas"+CHR$(34):PRINT:PRINT
40 A$(1)="##.## dB = ##.## dB + ##.## dB":B$(1)="             #.###   + #.###    "
50 FOR J=2 TO 5:A$(J)=A$(J-1)+" + ##.## dB":B$(J)=B$(J-1)+" + #.###    ":NEXT J
60 C$="Examples of equal power pads and their fractions "
70 C$=C$+"of input power absorbed:":PRINT C$:PRINT:ON ERROR GOTO 240
80 READ ADB,N:GOSUB 90:GOTO 80:DATA 3,2,10,4,30,6
90 ASUM=0:FOR J=1 TO 10:A(J)=0:NEXT J:FOR J=1 TO N
100 NUM=(N+1-J)*10^(ADB/10)+J-1:DEN=(N-J)*10^(ADB/10)+J
110 A(J)=10*LOG(NUM/DEN)/2.30259:ASUM=ASUM+A(J):NEXT J:P(0)=1
120 FOR J=1 TO N:P(J)=P(J-1)/(10^(A(J)/10)):PL(J)=P(J-1)-P(J):NEXT J
130 IF N=2 THEN PRINT USING A$(1);ASUM,A(1),A(2)
140 IF N=2 THEN PRINT USING B$(1);PL(1),PL(2)
150 IF N=3 THEN PRINT USING A$(2);ASUM,A(1),A(2),A(3)
160 IF N=3 THEN PRINT USING B$(2);PL(1),PL(2),PL(3)
170 IF N=4 THEN PRINT USING A$(3);ASUM,A(1),A(2),A(3),A(4)
180 IF N=4 THEN PRINT USING B$(3);PL(1),PL(2),PL(3),PL(4)
190 IF N=5 THEN PRINT USING A$(4);ASUM,A(1),A(2),A(3),A(4),A(5)
200 IF N=5 THEN PRINT USING B$(4);PL(1),PL(2),PL(3),PL(4),PL(5)
210 IF N=6 THEN PRINT USING A$(5);ASUM,A(1),A(2),A(3),A(4),A(5),A(6)
220 IF N=6 THEN PRINT USING B$(5);PL(1),PL(2),PL(3),PL(4),PL(5),PL(6)
230 RETURN
240 PRINT:INPUT "How many dB and with how many pads ";ADB,N:IF N>6 THEN N=6
250 GOSUB 90:GOTO 240


save "equipads.bas"

save "a:equipads.bas"


Examples of equal power pads and their fractions of input power absorbed:

 3.00 dB =  1.25 dB +  1.75 dB
            0.249   + 0.249
10.00 dB =  1.11 dB +  1.49 dB +  2.28 dB +  5.12 dB
            0.225   + 0.225   + 0.225   + 0.225
30.00 dB =  0.79 dB +  0.97 dB +  1.25 dB +  1.76 dB +  3.00 dB + 22.24 dB
            0.166   + 0.166   + 0.166   + 0.166   + 0.167   + 0.167

How many dB and with how many pads ? 20,3
20.00 dB =  1.74 dB +  2.95 dB + 15.31 dB
            0.330   + 0.330   + 0.330
```

where $j = 1$ to n.

At the immediately preceding (j
1)th attenuator is:

$$P_{j-1} = P_{in} - (j-1)(P_d/n)$$

where $j = 2$ to n.

Therefore, the attenuation of th
jth pad, called A_j, is given by:

$$A_j = 10\log_{10}[(P_j - 1)/P_j].$$ □

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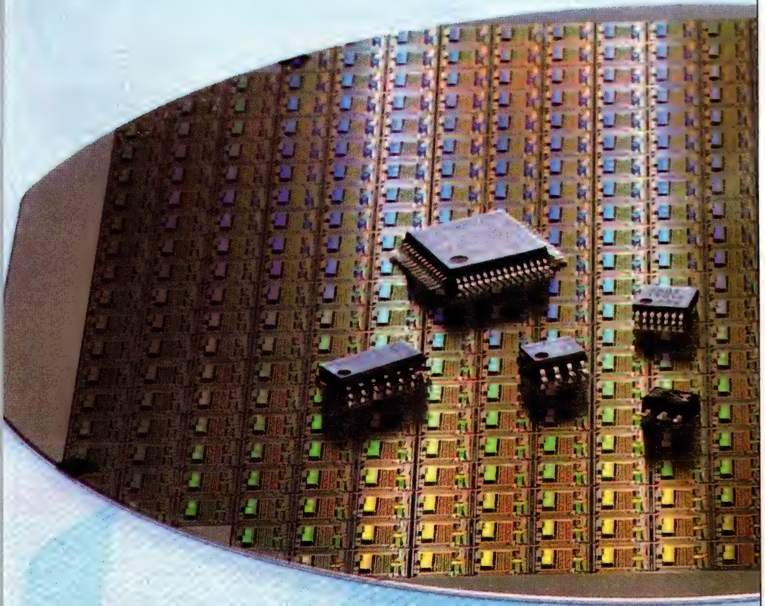

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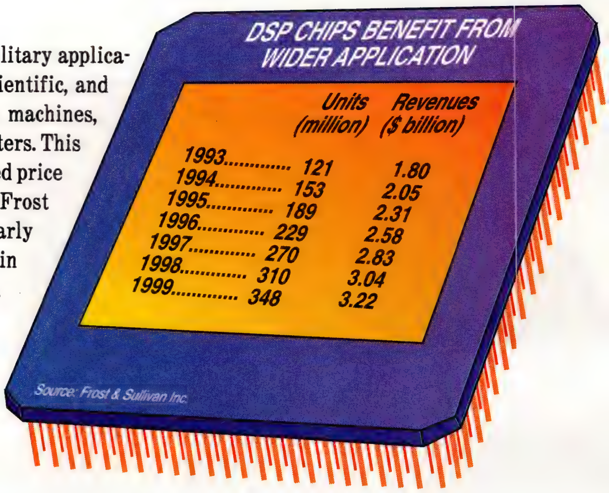
ELECTRONIC DESIGN

QUICK LOOK

EDITED BY SHERRIE VAN TYLE

MARKET FACTS

Digital signal processing has branched out from its origins in military applications to telecommunications, computing, industrial, medical/scientific, and consumer products. DSP chips have found their way into fax machines, modems, CD players, cellular phones, disk drives, and laser printers. This breadth of application, along with worldwide economic recovery and continued price declines, is propelling the sales of DSP ICs. According to market researchers Frost & Sullivan, Mountain View, Calif., worldwide sales of DSP chips should nearly double by 1999, increasing from $1.8 billion last year to reach $3.2 billion in 1999. Trends to look for: smaller device geometries, lower power consumption, and increasingly flexible devices. The biggest share of the market belongs to Texas Instruments. The Dallas company, first to develop digital signal processors, has about 58% of the single-chip programmable market, Frost & Sullivan points out. Other semiconductor companies with a stake in the DSP arena are Analog Devices, TRW (acquired by Raytheon Semiconductor), and Motorola. Vertically integrated companies such as Motorola and AT&T enjoy large captive markets for their DSP chipsets.



DSP CHIPS BENEFIT FROM WIDER APPLICATION

	Units (million)	Revenues ($ billion)
1993	121	1.80
1994	153	2.05
1995	189	2.31
1996	229	2.58
1997	270	2.83
1998	310	3.04
1999	348	3.22

Source: Frost & Sullivan Inc.

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Telenex Corp., a unit of General Signal Corp., has received an extension of its ISO-9001 certification to include Telenex Europe, Ltd. Data communication network products include Telenex 2700 Super Hub Systems for LAN and WAN, AR Test Systems, and Spectron and AR Tech Control Products. For more information in the U. S., contact Telenex Corp., 13000 Midlantic Dr., Mount Laurel, NJ 08054; (609) 234-7900; fax (609) 273-7688. CIRCLE 462

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PPM Associates, Inc., now has a revision to its ISO 9000 Compatible Workmanship Guide, labeled "ISO 9000 Electronic Printed Circuit Assembly Workmanship Guideline." The guide's drawings are available in two formats: single copies for individual use, and software files for large volume distribution and on-line applications. Contact PPM Associates Inc., 576 Charcot Ave., San Jose, CA 95131-2201; (408) 955-9180; fax -9182. CIRCLE 465

AMP, a supplier of connectors and interconnection systems, with headquarters in Harrisburg, Pa., has received ISO 9001 certification for design and production of board-to-board and wire-to-board interconnections in various facilities. Contact AMP, P. O. Box 3608, Harrisburg, Pa., 17105-3608; (800) 522-6752. CIRCLE 466

Pyramid Technology Corp., which builds and markets the MIServer line of servers and open computer systems, has received ISO 9001 certification for its product design, development, manufacturing, and customer service. Pyramid Technology Corp., 3860 North First St., San Jose, CA 95134-1702; (408) 428-9000. CIRCLE 467

Interleaf Inc. and Information Mapping Inc. has developed an Information Mapping template for the Interleaf 5 environment. Companies applying for ISO 9000 registration can use templates that combine information mapping methodology and Interleaf technology to electronically create and distribute ISO 9000 documents. Contact Interleaf Inc., Prospect Pl., 9 Hillside Ave., Waltham, MA 02154; (617) 290-0710. CIRCLE 468 graphical programming languages *have certain limitations when it comes to test development. •No one has figured out a way to let you create tests as powerful as the ones you're running now.*

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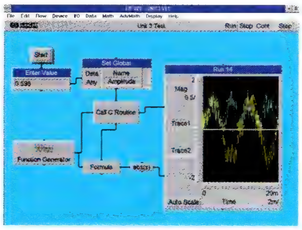

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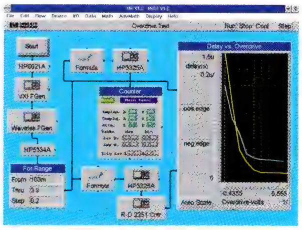

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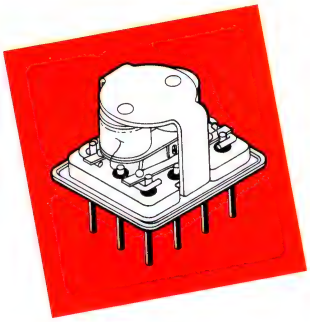
READER SERVICE 92

TO-5 RELAY TECHNOLOGY

THE HIGH PERFORMANCE GIGAHERTZ RELAY



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READER SERVICE 125

QUICK REVIEWS

Software and instructions for starting your own BBS (bulletin board system) are included in *The BBS Construction Kit* by David Wolfe, a veteran BBS operator. Wolfe answers common questions such as whether and how to set up a fee structure, what hardware and software to choose for specific BBSs, how to give the BBS a personality, and how to protect against viruses. The kit, which lists for $27.95, includes a disk with the GAP BBS software to install a 20-active user BBS, the Global Wars game, the Online e-mail package, an ANSI drawing and animation utility, and a quick door converter for running games and other software on the BBS (published by John Wiley & Sons Inc., ISBN 0-471-00797-8, 3.5-in., PC-compatible disk).

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Putting CAD within reach of PC users, GammaCAD Pro creates two-dimensional drawings of any object using its actual dimensions and prints at any scale on any Windows supported printer. Version 1.1 improves on version 1.0 by adding DXF file transfer to other programs, dimensioning commands, and more than 100 drawing symbols that can be inserted into designs. Drawings can be copied into the Windows clipboard (as a bit map) and pasted into a word processor to add technical illustrations to documents. Price is $25. For more information, contact Gamma Software, P. O. Box 8191, Fort Collins, CO 80526; (303) 490-2928; CompuServe 73737,1721.

CIRCLE 469

A white paper evaluates the architectures of high-performance, VME-based embedded computer systems. *The SKYchannel Technical White Paper* reviews circuit switched architectures, quick ring architectures, and packet bus architectures for use as communication options on and between VME accelerator boards. The white paper details SKY's SKYchannel packet bus architecture, which has been proposed to the VFEA International Trade Association (VITA) as a communication standard for VME-based systems. By providing an open interface specification, SKYchannel enables OEMs and integrators to accelerate their development schedules. The white paper is free for the asking from Sky Computers Inc., 27 Industrial Ave., Chelmsford, MA 01824; (508) 250-1920; fax -0036.

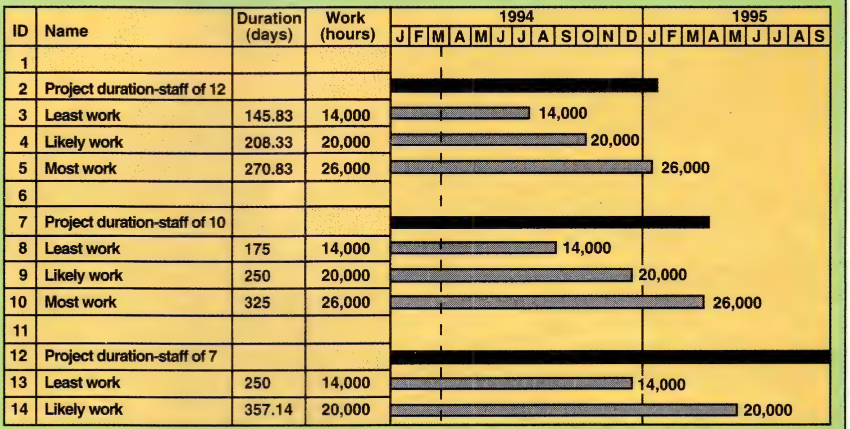
CIRCLE 470

KMET'S KORNER

...Perspectives on Time-to-Market

BY RON KMETOVICZ
President, Time to Market Associates Inc.
P. O. Box 1070, 100 Prickly Pear Rd., Verdi, NV 89439; (702) 345-1455; fax (702) 345-0804

Your new product development team has the data summarized in the illustration; 14,000 hours of least likely work comes from introducing a reduced feature and reduced performance product. You scaled back a 20,000-hour product definition to arrive at this figure. The 20,000-hour product is the one that you think would be the best for the market. It takes more work to get it, but collective wisdom suggests it would be worth it. The 26000-hour figure was derived by allowing things to go wrong on the 20000-hour effort. In fact, you allowed for the occurrence and resolution of six 1000-hour problems in your work quantity estimates. Let's explore our options to output a new product within a year.

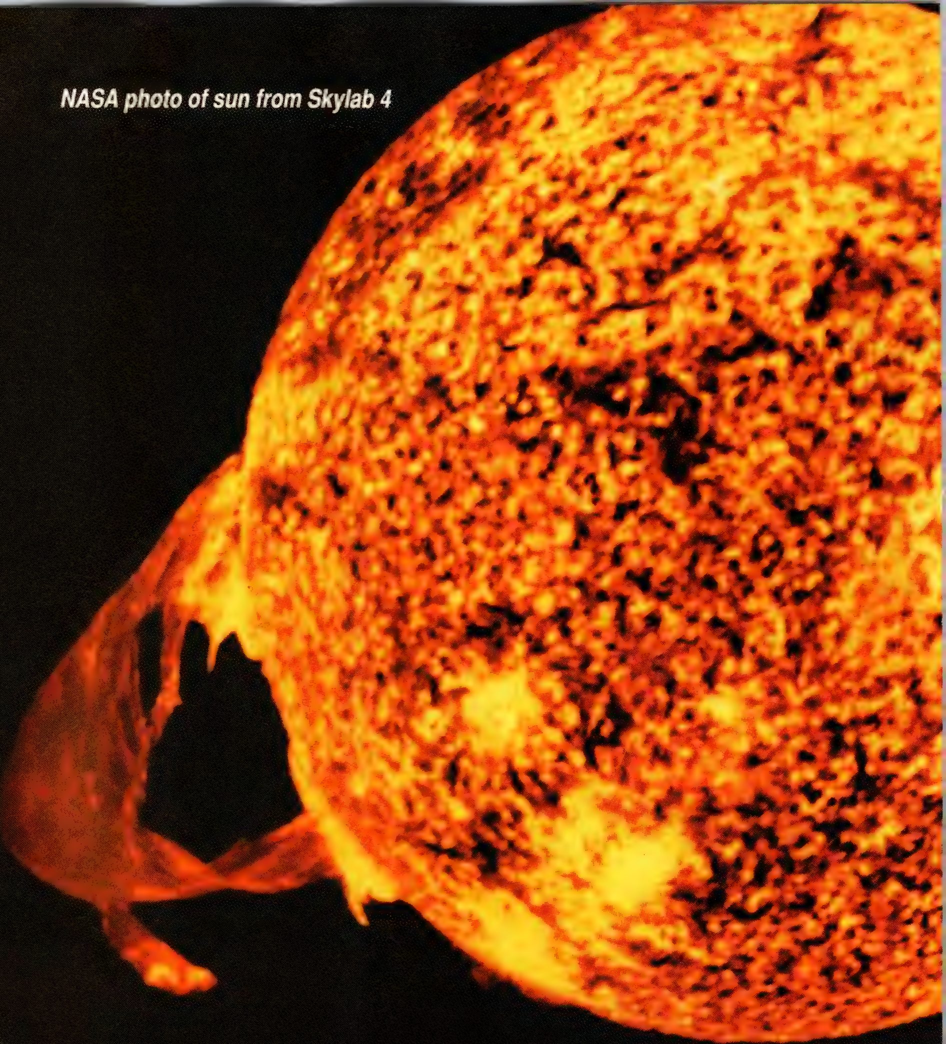


ID	Name	Duration (days)	Work (hours)
1			
2	Project duration-staff of 12		
3	Least work	145.83	14,000
4	Likely work	208.33	20,000
5	Most work	270.83	26,000
6			
7	Project duration-staff of 10		
8	Least work	175	14,000
9	Likely work	250	20,000
10	Most work	325	26,000
11			
12	Project duration-staff of 7		
13	Least work	250	14,000
14	Likely work	357.14	20,000

With the work quantity data in your possession, you exercise the database. With 12 staff members, you could finish the scaled product in 146 working days, the nominal product in 208 days, and a nominal product that encounters difficulty in 270 days. It is safe to say that with a staff of 12—working 5 days per week at 8 hours per day—you could meet or beat the one-year objective under most any product configuration and difficulty condition.

Restricting staff to 10 removes one of the available options. You can do the 14,000-hour and 20,000-hour alternatives, but if you elect to do the 20,000-hour product, you do not have the capacity to remove problems should they be encountered without increasing commitment. If you select this path, you have to make a few difficult choices. My bias leans toward the 14,000-hour alternative. You then have capacity, up to 6,000 hours of it, to encounter and resolve unanticipated occurrences without working extended days into the weekend. This option gets product as it holds normalized team commitment figures below 1. If you take on the 20,000 hour option with a staff of 10 and things go wrong, your team will have to work extended days and weekends or you'll have to slip your schedule. This may be a realistic alternative, but make sure the team knows what will be expected of them if problems do arise.

A staff of 7 could output only the 14,000-hour product. If they encounter any problems whatsoever, they have to work long days and weekends in proportion to get product in a year or less. You should not even consider doing the 20,000-hour product with a staff of seven. Taking this path would mean long days and weekends from the start. Unanticipated problems would mean even longer days and more weekend hours. If you want the 20,000-hour product and you want to keep team commitment around 1, staff the project with 12. With only 10 staff members, do the 14,000-hour product, which keeps commitment in check. If you're willing to expand commitment, you could do the 20,000-hour product with a staff of 10. With staff limited to 7, the 14,000-hour product is the only reasonable choice.


NASA photo of sun from Skylab 4

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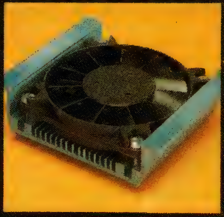
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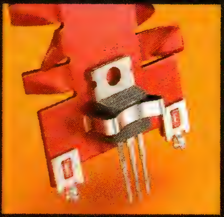
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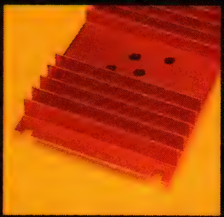
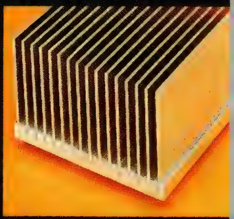

The higher the pow the more we can h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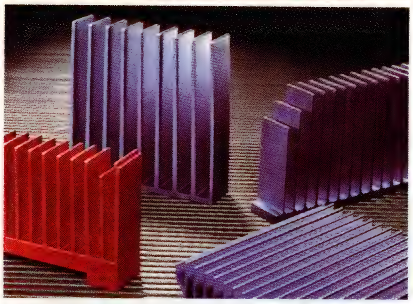

High fin density: peak cooling

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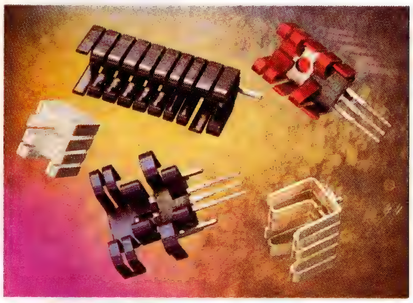

Plug-in heat sinks cool TO-220s

Compact heat sinks for TO-220s plug in quickly. Cut labor costs by eliminating nuts and bolts. Fins form spring action clips that hold semiconductors securely for superior thermal performance. Small footprint (as little as 1/2" sq) saves valuable space.

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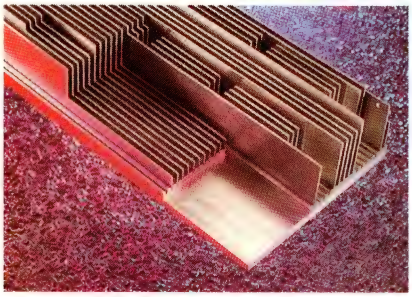

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MY VIEW

...Stillman

BY FRANK J. BURGE

Director of Market Development for Electronic Design

Eight weeks ago Charlie Stillman died. I had known Charlie for more than 20 years and in all that time I never heard him say an unkind word about anyone. He always greeted me with a smile, a warm handshake, and a hug, even when we were competitors. It was as if he really cared—and he did. Now you may never had heard of Charlie but back in the '60s he was a salesman for *Electronic Design* and later the publisher of *Electronic Products* magazine.

In the '70s he helped Gerry and Lilo Leeds start a publishing company called CMP. Working together with a beginning journalist named Paul Hyman, they launched *Electronic Buyers' News* and two years later, *EE Times*.

In the beginning they worked out of the living room of the Leeds' home in Great Neck on Long Island. Now Gerry and Lilo have retired and passed the business on to their son Michael, who has built it into a quarter of a billion dollar publishing empire.

Stillman retired from *EDN* magazine when he was into his seventies and then signed on with a rep firm covering the Southern California territory out of his digs in Las Vegas. Charlie loved Vegas. Over the years I cannot recall an industry conference or convention where I did not run into Charlie. He was everywhere. A mutual friend, Dan Bellack, once told me it was impossible for Stillman to be in so many places at once so Dan figured Charlie had developed a franchise for the lonely. For twenty-five bucks he sends you a Stillman mask and tells you where to hang out. It's guaranteed that someone will come up and pat you on the back, give you a hug, and tell you how glad they are to see you. The Stillman mask worked magic.

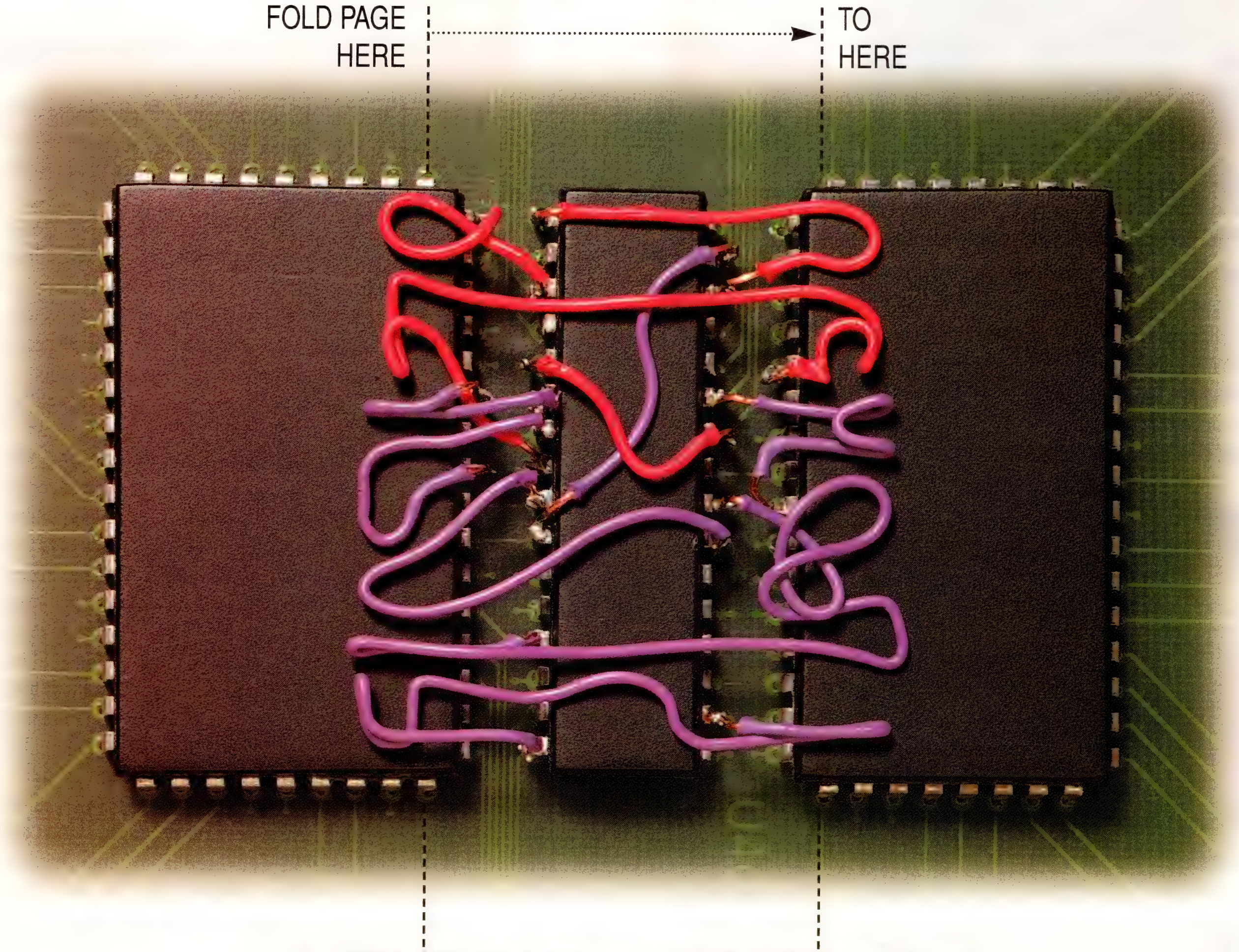
After Charlie died, 103 of his closest friends got together for dinner, memories, and to wish him well in the new territory.

So why do I bother telling you about a 70-year-old coot who was a friend of mine? Don't you have more important things to deal with, such as coping with technology that's advancing by the nanosecond or fending off competitors who will eat your lunch if you blink or juggling a development schedule that calls for volume production before you've had a chance to start the design? Isn't that the important stuff? Nope.

The important stuff is what you do before and after—the stuff in the middle. And you know what? Stillman had it figured out. He'd help a friend build a publishing business but once it was properly launched, Charlie was off being Charlie. Being alive and enjoying life were important to him.

Don't get me wrong—Stillman loved work and always gave an honest effort and consistently delivered results that kept the bean counters smiling. But he also had a certain perspective about work and living—living came first. I always envied Charlie for that.

Now I recognize that business today is more competitive than it was in my beginning days in this industry. And maybe that's why so many people I meet lately are so intense, just more uptight than they used to be. They never seem to have time to take a giggle break—as if they have life and work mixed up. For many the fun has gone out of the business, or is it just my imagination? But come to think of it I also run into more rude people that I used to. People who just don't have the time to smile on the telephone or even return phone calls. Too busy I guess. And I'm as guilty of it as anyone. Where have all the Stillmans gone?



SURE, RECORD-BREAKING SPEED IN A COMPLEX PLD IS A BIG PLUS BUT IT SHOULDN'T ROUTINELY BE A TEST OF YOUR ABILITY TO HANDLE PLIERS.

(FOLD AS SHOWN FOR THE ALTERNATIVE.)

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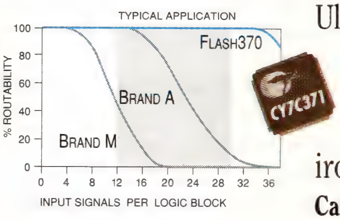

The FLASH370 family's exceptionally clean and simple architecture helps get your products to market faster. And as part of Cypress's comprehensive UltraLogic™ family, the FLASH370 is supported by *Warp*™ VHDL open design tools. So start designing with a data sheet instead of a soldering iron. And watch the competition fold.

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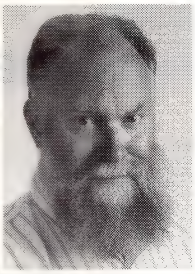
ULTRA LOGIC

CYPRES

PEASE PORRIDGE



BOB'S MAILBOX

Dear Bob:

Thank you for your questioning series on Fuzzy Logic and the many claims that have been made for it. Maybe F.L. has a lot going for it, but I have yet to find a clear case of where apples have been compared with apples. I hope a proponent of F.L. can clearly show one. I have read three of the recommended texts on F.L., numerous magazine articles and still remain unconvinced. (Though I must admit the articles by James Sibigtroth of Motorola are persuasive.) The Sendai subway train is often quoted as an example of how good F.L. is. But where is a complete and analytical comparison with a good proportional controller implemented in conventional logic?

What has especially clouded the case for F.L., for me at any rate, is the puerile, insulting, and trivial treatment of its supposed advantages. Let me give you a couple of quotes:

1) "Fuzzy Logic lets you assign values instead of crude categories. For instance, if we arbitrarily defined old as over 40, a woman who was 41 would be offended by the old label. With F.L., we can assign membership values to the young and old sets." Really! I'd just call her 41 and avoid any fuss. It's not that I'm a feminist, it's just my analog upbringing.

2) "F.L. does not constrain us to use one or zero, instead we can use intermediate values." Oh great, here I've been thinking that 8-bit micros can support 256 discrete values. Oh well, I learn something new each day.

With this sort of crappola being quoted as reasons why we should embrace F.L., I can get a tiny bit cynical about it. Please, can we see some serious proof from a F.L. proponent?

BARRY T LENNOX
Wellington 4
New Zealand

Barry, we haven't stopped looking for good Fuzzy comparisons. When we find one, we'll let you know.—RAP

Dear Mr. Pease:

I myself might have had an encounter with Roy McCammon's truck-stabilized riometer (March 21 issue) at McMurdo Station, Antarctica a couple of years ago.

I was asked to look at the instrument in question, which was indicating random anomalous bursts of RF energy once or twice a day. The chart recorder indicated only increases during these episodes, so the problem has to be noise or RFI, right? We couldn't use the "diagnostic truck" because some genius had measured the gasoline in the tilted main storage tank at the deep end only, so we were running out of this fuel, and it was three months until the next tanker was to arrive.

So we checked the power supply, walked the cable lines, wiggled all the connectors, took the remote receiver and antenna apart, tried to blame the Navy's 7-kW HF transmitters, tried to blame the power system, scratched ourselves in various places, had a beer, and went to bed.

Next day, out of ideas and probably out of instinct, (I grew up with vacuum tubes), I started pounding on the equipment racks. Lo and behold, the bursts appeared.

The problem was found in a matrix switch for the output of the riometer that was the product of some helpful fellow who had never gone to soldering school.

Why did the output rise during the fault? Two devices shared the low-impedance signal, one high impedance and the other with a substantial positive input bias current. I don't think it was one of your parts. The lessons? 1. If you haven't proven the problem, you probably fixed the symptom. 2. If the problem is smarter than you are, kick the damn thing.

BILL SCHMITT
Digiserv Inc.
Mound, Minn.

Just as I said in my book on p. 143—when working with intermittents, apply a little FORCE!—RAP

Dear Bob:

Thank you for the voice of sanity on the QUALITY stuff. We are a semiconductor division of a large power-supply company. Ever since we first started, we have been using our own, practical, appropriate standards of quality to ship the best parts we could. And we have had the right to fight people, quality experts even, who want to impose rigid standards on us that would actually cause us to ship *more* bad parts to customers, even though we would then conform to a "high quality program."

(Personally, I am of the opinion that it is impossible to create a documentation and specification system that makes a process idiot proof. I confess to having picked up a phrase of yours as an existing operating motto: Thinking is required.)

Our quality philosophy comes down to this: If it smells fishy, don't ship it. How do you know when it's fishy? Smell it, taste it. In other words, test the hell out of it.

- And look at the data.
- And use your intelligence.
- And be skeptical.

There are parts that pass all of the data-sheet specs, but have a parameter that falls outside the usual distribution (note that I do not say "normal" distribution—more later). If you look at the histogram of the parameters of a large number of units, these are the parts in the "tails" of the distribution that trickle away from the main body of the material, yet remain within specification. Those are fishy. They're not the same as the others. Get rid of 'em. Common sense, and many years of analyzing customer returns and field failures, tells me that these are likely to be the parts that give customers conniptions, even though the data sheet tells me there's nothing wrong with them.

Historically, we built product exclusively for our own mother company. But one of the reasons a tiny little 40-person division like ourselves is now generating sales to major outside customers is that our philosophy hasn't changed. When you have only one customer, it's in your best interest to make damn sure that the customer will like every part you ship, and "like" is not an objective criterion by any means. "Liking" our product includes, but is not limited to, complying with the data sheet. "Liking" our part also means, "Does it function?" Bizarre as it may seem on the surface, I bet any field applications engineer will be able to tell you about cases where the failed part met every data-sheet parameter, yet didn't function.

More importantly, "liking" our product means, "Is it the same as all of the other material we've been shipping?" The IC engineers in this division wish in their hearts that our customers would actually design with data sheet min and max tolerances in mind. But the fact is, most of the time they just look at a few typical sample pieces and see if their circuit works. Often the IC is just one of dozens of components on a board, and a pretty insignificant one at that, and if they were to actually try to design around a full-spec tolerance of our chip, they couldn't build their product. Yet, in reality, they *do* build their product, and a lot of it, to a high-quality level, and make a profit on it along the way.

So we take the view that, to consistently receive our paychecks, we have to protect the customers from themselves to a large extent. We have to understand their designs thoroughly, from the point of view of the chip, so that we can anticipate where normal variations in *our* process will cause *their* designs to fall out of bed. And usually this means that we have to put intelligent guard bands around our typical distributions. We have to test the parts to know that what we ship is the same as it's always's been.

There's another benefit to this philosophy. It produces de facto control limits on our process that reflects the actual "quality" our customers require. And we also find that there are parameters that, while spec'd in the data sheet, really don't matter to the customer. So then, an intelligent guard band on testing is simply the test resolution within the data-sheet limit.

This brings us back to parameter distributions and the so-called quality programs. We have a number of parameters, like any analog IC manufacturer, that have to be trimmed. Offset voltage of amplifiers and the output voltage of references are the obvious examples. Acceptable process variations create product parameter distributions that do not meet specification, so the product must be designed to allow this parameter to be trimmed. We have had customers and their quality experts insist we "fix" our fab process so that this wasn't necessary, or redesign the product so that the parameter in question becomes "independent" of process. Well, when your products have a bandgap reference, it's a little difficult to design the reference value to be independent of V_{be}, since it is that very dependence which forms the basis of the circuit in the first place! If you want a tight reference, you're going to have to trim it.

Now, trimming produces a little oddity that *really* confuses quality people. When you get done trimming a reference, for example, you have taken all of the parts and modified their circuitry so that their reference value falls within a very narrow window. The final distribution looks like a box, with absolutely vertical sides and an almost uniform distribution of material within the limits. Then, generally, we get one of two questions:

1) "What happened to the rest of the parts?" In other words, they think we've artificially lopped off the sides of the distribution, which is actually true, but not in the way that they think.

2) "How do you expect to stay within tolerance?" In other words, they calculate the mean and standard deviation on the histogram we sent them, set the 3-sigma limits, and complain that we are going to be out of spec.

Both questions indicate, of course, that they think our quality is going to be lousy because they don't see a NORMAL distribution nicely centered within large process guard bands. And we have to explain, patiently and concisely, that they aren't going to get, ever, any parts that fall outside the spec window, due to the very nature of the trim procedure.

An important footnote to trimming: It is absolutely critical to lop off the "tails" of the distribution, as described above, *before* trimming the parameter. Designers often include enough range in their trim scheme to allow these tails to be trimmed back into the main distribution, at which point you'll never find the anomalous parts to get rid of them. This is definitely one of those places where testing is critical to maintaining the quality level.

MARC DAGAN
Senior Design Engineer
Astec Semiconductor Div.
Milpitas, Calif.

Marc, I agree with you on ALL points. Any time you have to re-educate a "Quality Expert," you're doing us all a favor, and I'll support you on that. I hope I have been helpful in deflating the infallibility of "Quality Experts."—RAP

Dear Bob:

I am responding to your Feb. 7 column regarding Dr. Deming and the testing of semiconductor products.

While I am by no means a student of the history of quality control, I believe that you are mistaken in your assertion that Dr. Deming spoke of a need to eliminate all testing for a product and manufacturing process to be deemed "good quality."

Dr. Deming's claim to fame was the application of statistical methodology in the direct management of production processes by the operators and first-line supervisors themselves. It was he who advocated putting the quality assurance into the hands of the operators, as opposed to separate inspectors.

Now, it shouldn't take a PhD to realize that an application of statistical methodology implies the collection and analysis of data. What data? Why the results of in-process testing, of course.

In-process testing can be as simple as the visual inspection of a molded coffee cup or as complicated as the complete parametric analysis of a semiconductor product.

Deming, Juran, and the lot all advocate the liberal use of production process feedback, applied as early in the process as possible. Their gospel has always been one of pushing the testing "up the supply chain" and to eliminate the need for *redundant* testing, as epitomized by the classic model of an incoming inspection department that examines everything coming in the door.

J DAVID EGNER
Compliance Engineering Manager
PowerHouse Systems Inc.
Menlo Park, Calif.

David, we do lots of testing early in our fab, and intermediately, too. But we still depend on Final Test, and so does every other semiconductor maker. If our tester is down, we can't ship!—RAP

Dear Bob:

Re: Your Feb. 7 column on quality. Stripped of its prose, the argument against end-of-line (EOL) testing invariably boils down to the idea that given 100% confidence in the raw materials and the manufacturing process, you need not test the finished product.

I gleaned from your article that the combination of a 40% yield manufacturing process with a 99.995+% confidence EOL test is an economically favorable way of producing high-quality goods in the semiconductor industry, despite the high rejection rate and the cost of testing. This is so because the rejected goods have little intrinsic value, and the tests are quick and cheap compared with the cost of increasing the confidence in the production line.

This would tend to support the notion that the world is not black and white, but a shade of gray. For any given manufactured good, the economically optimal balance between production-line confidence and EOL is not 100% vs. 0%, but somewhere in-between.

N. LANDMARK
Sagem-Lucas
Birmingham, England

You have paraphrased my points, setting them in a new light very nicely. A little practicality beats platitudes almost every time. Deming knew that.—RAP

All for now. / Comments invited!
RAP / Robert A. Pease / Engineer

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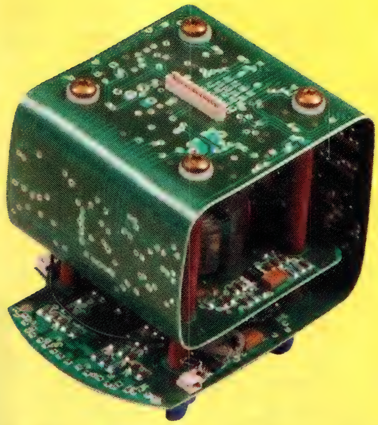

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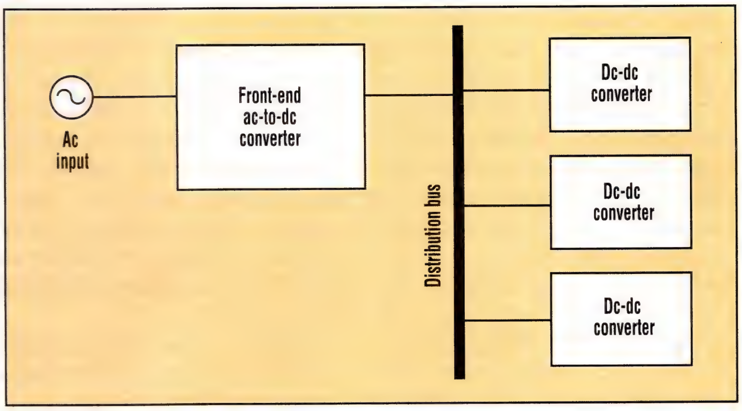
Powering DC-DC Converters In A Distributed System

The distribution-bus voltage is a key decision.

BY GABRIEL G. SURANYI

AT&T Power Systems, 3000 Skyline Dr., Mesquite, TX 75149; (214) 284-8219.

At first glance, the generating topology's design and the chosen voltage level of the distribution bus for distributed power systems seems simple and inexpensive *(Fig. 1)*. Key factors in distributed-power design include the impact on dc-dc-converter schemes, system integration, and the flexibility of the chosen power system. But in practice, the choice of the voltage bus is very important, and its optimization within a distributed power system requires careful design engineering.



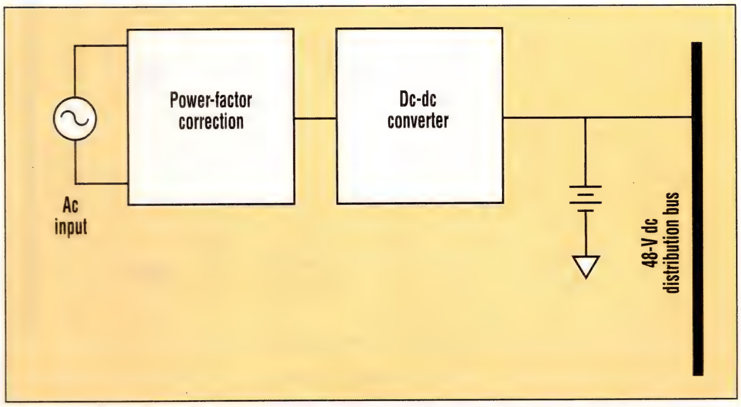
1. To the casual observer, the design of the generating topology and voltage level of the distribution bus for distributed power systems seems simple and inexpensive. But in practice, the choice of bus is very important.

On the surface, it appears as if any unregulated or quasi-regulated ac-dc supply generated by a convenient topology should suffice for power distribution. It should be trivial to feed this voltage downstream as inputs to the dc-dc converters. However, while this approach may produce a workable power system, it doesn't produce optimum results. Cost savings realized from a quick design may result in higher overall power-system costs, limit the end product's market potential, require higher system-development costs, and delay the product's launch.

Consequently, designers of distributed-power systems are faced with two important challenges. First, they must choose the best distribution-bus voltage level for their system. Then, they must design and optimize the various building blocks formed around the distribution bus. These building blocks include ac-dc rectification, dc-dc conversion, distribution, protection, and reserve-scheme implementation.

Because most early distributed-power systems were designed for phone uses, the natural voltage choice for the distribution bus was the same 48 V used to power much of the telecom network. Other low-voltage bus levels have surfaced, though. For example, the wireless industry standardized on 24-V systems because of the 24-V source required by power-hungry radio transmitters.

As distributed-power concepts evolved outside of the telecommunication industry, higher distribution-bus voltages of 300 and 400 V emerged. Such high-voltage distribution buses appeared to be less expensive and generated lower losses than



2. It's no coincidence that the typical low-voltage buses of 24, 36, and 48 V are simple multiples of the 12-V battery string. But increasing the number of series-connected cells complicates battery control and charging. That's why most backup batteries fall into the 12-to-48-V range.

low-voltage buses. Along with the high-voltage buses came new families of dc-dc converters that could accept these high voltages.

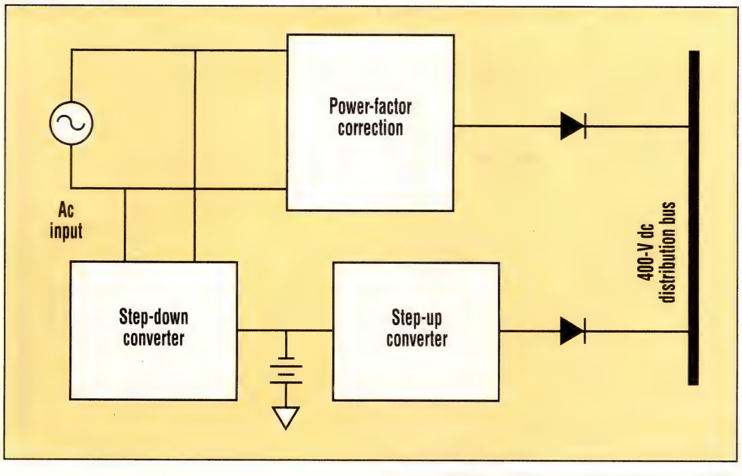
Such distribution buses provide radically different features. It's important to understand these differences and determine which architectures will optimize the needs of a given power system.

A number of crucial, interlinking factors must be evaluated to assess their impact on the distribution system's design. Primarily, these include determining how much energy is dissipated by the distribution system; what effect the distribution system has on backplane and system circuit development; and the relationship between bus-voltage levels, design complexity, and the development schedule. The evaluation process should recognize that the distribution system will most likely be a multilayer printed-wiring-board backplane carrying a substantial number of signal pins.

Because backplanes must provide structural integrity as well as electrical connectivity, they're traditionally complex and expensive—both to develop and procure. Backplane design is further complicated by the growth in signal-pin connectivity between circuit boards. Such growth is driven by increased functionality brought about by modularity and higher levels of circuit integration, the migration to higher clock speeds, and data-transmission rates as well as the evolutionary shift from 5-V to 3-V semiconductor technology. Although the new generation of 3-V ICs may run faster while consuming less power, they're more susceptible to conducted and radiated emissions. These factors all suggest the need for even more flexible, unrestricted, optimized backplane designs to achieve a desired performance level and improve isolation between signal paths.

The surface-area requirements of the power-distribution system and the power consumed during distribution are critical because they constrain the layout of backplanes. Distribution systems, even those consuming less than 1000 W, carry an appreciable amount of current. Such high currents require that heavy-gauge wires, or copper traces with large cross-sectional areas, be used to minimize the I^2R losses throughout the distribution system.

Clearly, from the standpoint of power losses, distribution buses with higher voltages are a better option. For example, a distribution bus in the 300-to-400-V range carries about one-tenth the current drain of an equivalent 48-V system. With such a significant current reduction, it appears that much smaller distribution buses can be used with a corresponding reduction in dedicated backplane surface area. However, the space savings realized by lower current drains in a high-voltage distribution bus are more than offset b clearances required to meet safety-agency specifications.



3. Meeting safety standards with a high-voltage bus can be simplified by using a low-voltage battery, a separate charger, and a step-up dc-dc converter. Adding step-down chargers and step-up converters may seem expensive, but high-voltage batteries are far more costly than 12-, 24-, or 48-V equivalents. The savings from using a low-voltage battery can offset the cost of conversion.

ED/COA4891/Fig. 3

From the standpoint of safet considerations, the choice of 48-V distribution in telecommunication equipment was significant. Distribution voltages o less than 60 V are defined by th safety agencies as "extra-lo voltages" (ELVs) that pose n shock hazard and, therefore, require no special attention. Distribution voltages in the 300-to-400-V range, however, are considered lethal and must be adequately isolated. In backplane and on circuit boards carryin such voltages, this means observing the creepage clearance specified by various standards.

The primary concurrent safety standard throughout th western world is EN 60950 (it predecessor is IEC 950). In th U.S., UL 1950 is the harmonized equivalent of EN 6095 Basic clearance requirements o EN 60950 call for at least a 6.8-mm separation between primar and secondary circuits. Ther must also be at least 2.5 mm between adjacent primaries an between each primary circui and frame ground.

It turns out that 300-to-400- distribution buses are recognized as primary component because they're derived fron circuits that aren't isolated from commercial ac power. Backplane design must address th partitioning of these circuits an their isolation from secondar logic interconnectivity. So, although the high-voltage distribution bus requires less surfac area in the current-carryin paths, it needs at least an equivalent amount of surface area t meet the clearance standards.

Other important design constraints also influence decision on distribution-bus voltage levels. Gaining safety-agency approval is usually a time-consuming process that requires substantial design expertise. However, because technolog advances so rapidly, product

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based on new technology must be marketed quickly to avoid being supplanted by an up and coming technology. For this reason, manufacturers must do whatever they can to ensure their products gain safety-agency certification as quickly as possible. Many nations require that electrically-powered products sold within their borders be certified to their national safety standard. Even when certification isn't mandated, market pressures often force products to toe the line.

Because voltages below 60 V are considered safe, safety agencies don't worry themselves with its distribution throughout the product under evaluation. But they do closely examine the distribution of higher voltages. In particular, most safety agencies evaluate the performance of critical areas, such as the backplane, when faults are introduced intentionally. Designers of these higher-voltage systems must endure the lengthy process of backplane certification. Of even greater concern, designers must have the backplane recertified every time a modification is made to either the primary or secondary circuits. This is a lengthy and costly process.

Also crucial when choosing the distribution voltage is its effect on pin-field assignments, selection of connector styles, and routing constraints. When a high distribution voltage is used, the connector pin field must provide the required separation clearances between circuits. The chosen connector also must be suitable for primary-circuit applications. Often, this latter requirement rules out using the densely-packed connectors that are favored in modern designs.

Use of a high-voltage distribution bus also affects the downstream dc-dc converters and their associated system boards. To meet safety-agency requirements, each of these converters must provide for basic and supplemental insulation. In addition, the pc board containing the dc-dc converter must be designed to meet the required safety clearances. Conversely, primary-to-secondary-voltage isolation isn't needed when extra-low distributed-voltage levels are used. Because ELV circuits are all considered low-voltage secondary circuits, the circuits boards containing the low voltage dc-dc converters needn't be submitted separately for safety-agency certification.

Summarizing these safety implications, high-voltage buses require rigorous understanding of safety issues, and the components used must meet safety specifications. In particular, components like backplanes and system circuit packs, which contain the downstream dc-dc converters, must be submitted for safety certification. Such time-consuming details could curtail time-to-market initiatives.

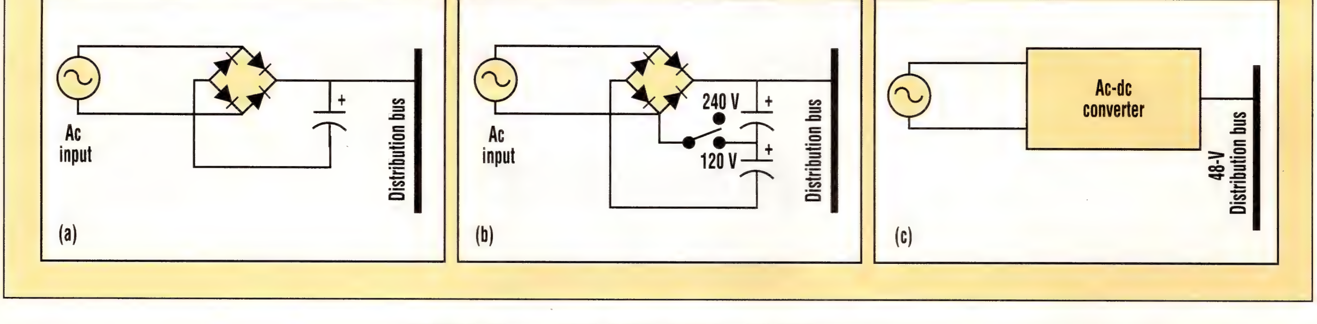
Although safety-agency requirements play a vital role in the selection of the distribution-voltage level, that voltage's affect on system performance also should be considered. Two important, and interrelated, performance criteria are dc-dc-converter efficiency and both conducted and radiated EMI suppression requirements.

Converter efficiency depend heavily on switching speed an rapid transitions of the switching elements from their conductive to passive states. Unfortunately, these characteristics als contribute significantly to th generation of EMI. Because efficiency typically is of paramoun importance, power-system designers generally specify highe switching speeds, even though i leads to greater conducted an radiated EMI. System designer then are left with the task of containing the noise emissions. Th difficulty of that task depends o the selected distribution voltage

For any given switchin speed, increasing the distribution voltage increases the dv/d switching transition. Conversely, for a given power level, decreasing the distribution voltag increases conduction currents Thus, using lower bus voltage means higher distribution currents and higher di/dt switchin transitions.

Nonetheless, EMI filterin generally is simpler when a low voltage distribution bus is use due to two factors. One, a muc larger selection and less expensive variety of filter component is available at the lower voltag ratings. Two, these component are an order of magnitude smaller than their high-voltage counterparts.

Still another consideration i selecting a distribution-bus voltage is the power system's uninterruptibility. Because the demand for power in many areas o the world is increasing faste



4. Before choosing a distribution-voltage level, designers must address trade-offs in the design of the ac-dc front-ends required to generate the distribution voltage. The least expensive approach is to use the same kind of bridge-rectifier circuit typically used in an off-line switch-mode power supply (a). If a voltage doubler is used, the voltage range could be minimized to between 240 and 380 V (b). The lack of regulation can be addressed by inserting a dc-dc converter between the rectifier and the distribution bus (c). This converter can be a separate unit or it could be part of the ac-dc front-end generator.

ED/COA4891/Fig. 4

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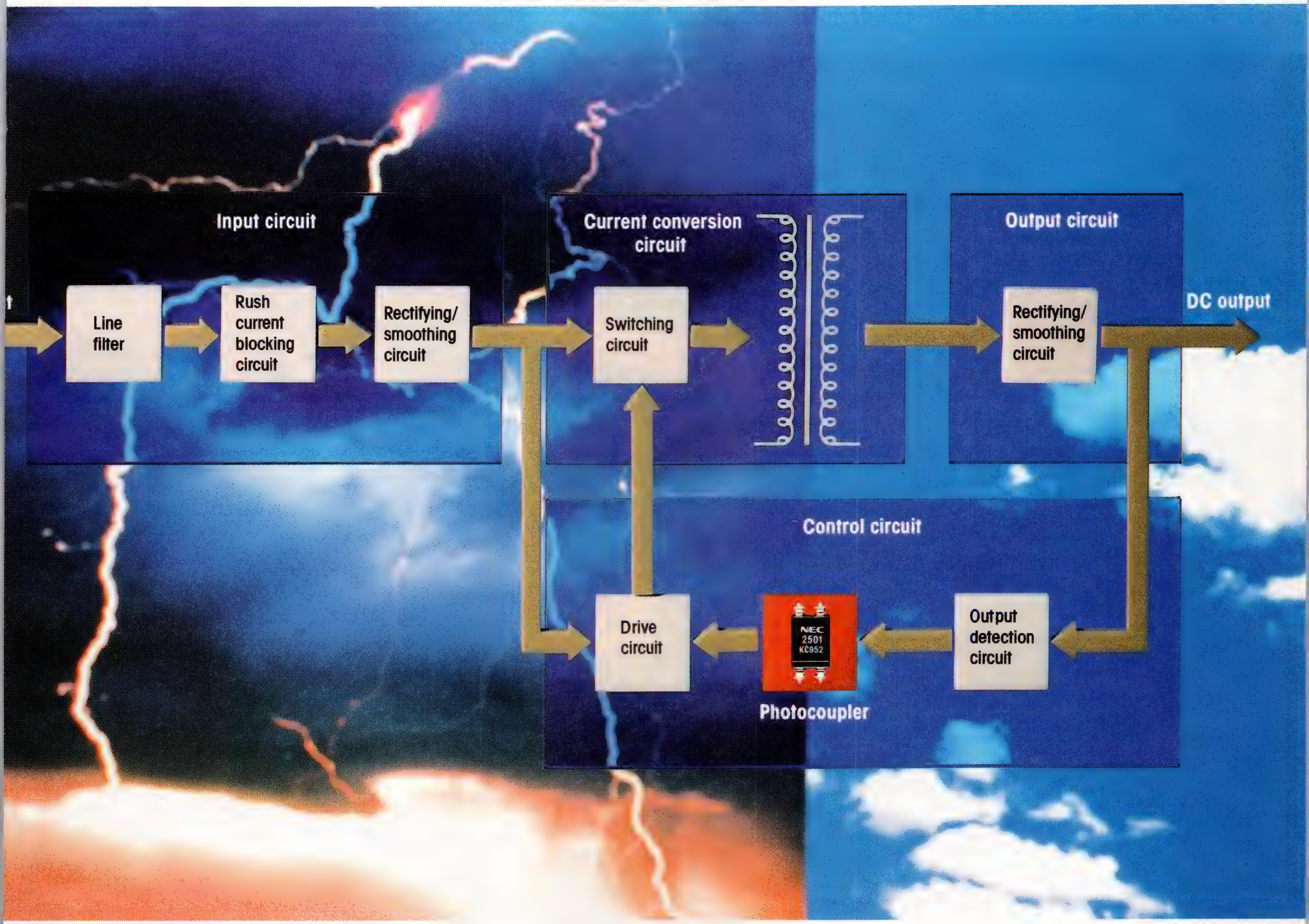

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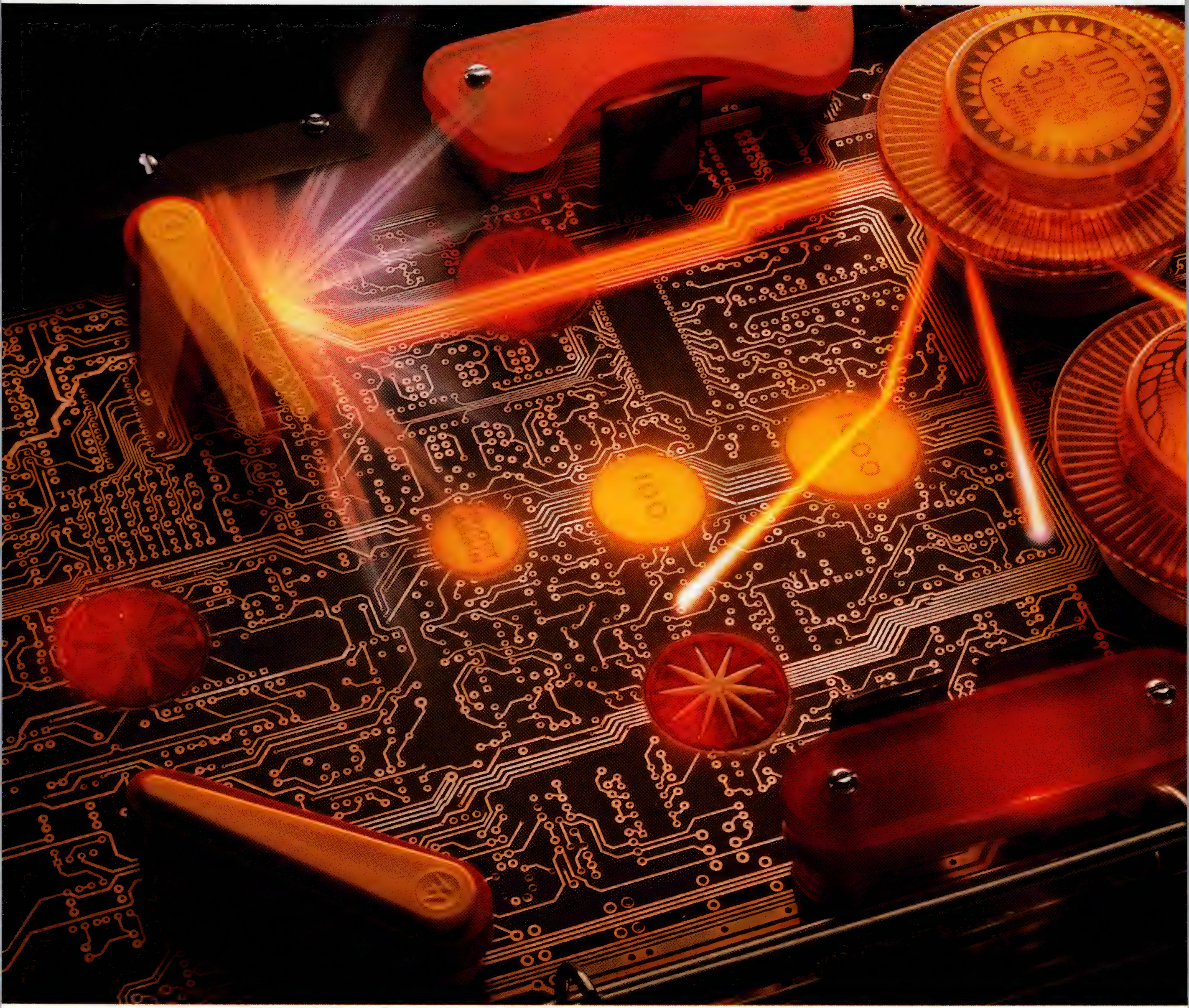

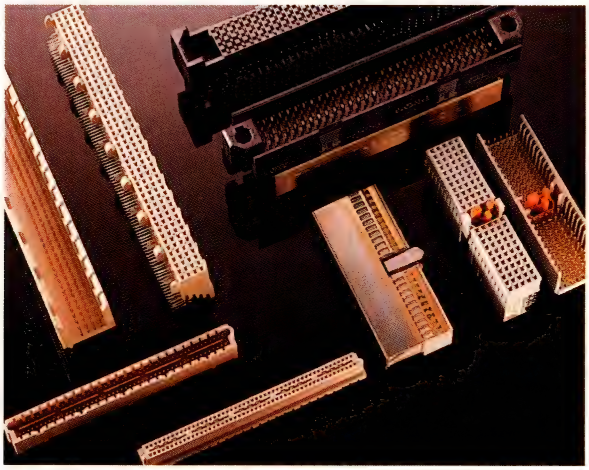

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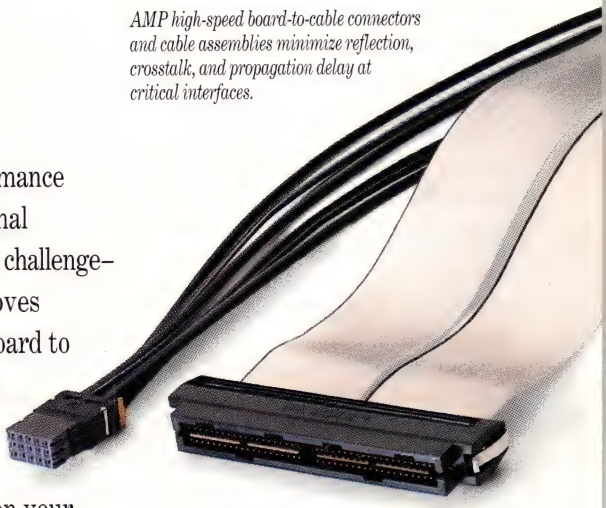

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than generating capacity, the quality of ac-utility power is eroding. U.S. utility power is far superior than that available elsewhere, but it too is eroding. This decline is further fueled by the increasing sensitivity of modern electronic components to transients on the power line. The result is more frequent power sags, brownouts, outages, and equipment disturbances.

Traditionally, designers have used external battery-backup systems or uninterruptible power supplies to protect their systems against ac-power problems. Removing ac fan motors and 60-Hz power transformers from modern electronic systems eliminated the need for an uninterruptible source of ac power. Now, an uninterruptible source of dc power serves to ensure continued system operation. This means the battery-backup function can be moved inside the system. Recent innovations in battery technology, resulting in dramatic size reductions and usable life improvements, further contribute to their potential consideration within the system equipment.

The simplest, least expensive approach to internal backup is to connect a battery of sufficient capacity directly across the distribution bus. However, bringing battery backup into the system complicates the choice of distribution voltage. Most backup batteries consist of several series-connected 2.2-V cells. A 12-V battery, for example, consists of six series-connected 2.2-V cells. Low-voltage distribution buses of 24, 36, and 48 V are simple multiples, not by coincidence, of the 12-V battery string.

Increasing the number of series-connected cells also increases the complexity of the battery's control and charging functions. For these and other reasons, there are limits on the number of cells that can be stacked into a battery. To minimize cell stacking and cost, most backup batteries fall into the 12-to-48-V range *(Fig. 2)*. Batteries delivering 100 V or more often aren't used in backup service. In addition, safety requirements for ELV levels apply to batteries as well. However, if care is taken in the selection and integration of the constituent cells, backup batteries supplying 300 to 400 V can be used.

Using backup batteries to maintain system operation saddles designers with the problem of maintaining their charge in a cost-effective manner. The simplest, least-expensive approach is to use the distribution-voltage level already present. However, as mentioned above, this may involve special precautions to meet safety agency requirements when the battery is charged from a 300-to-400-V distribution bus.

Compliance with safety requirements for high-voltage distribution buses can be simplified by using a low-voltage backup battery, a separate charger, and a step-up dc-dc converter to connect to the high-voltage bus. At first glance, using step-down chargers and step-up converters appears to be a very expensive alternative. However, high-voltage batteries are considerably more expensive than common 12-, 24-, or 48-V equivalents. The savings achieved by using a low-voltage battery will at least partially, and perhaps completely, offset the cost of step-down and step-up converters *(Fig. 3)*.

To summarize, interfacing batteries to high-voltage buses is substantially more complex than direct linking, which can be achieved with battery strings connected directly across low-voltage buses. In addition to complexity, the resultant reserve system for high-voltage buses requires more space, is less efficient, and offers reductions in performance and reliability.

From the preceding discussion, it's apparent that the choice of distribution-bus voltage level isn't as simple as it appears on the surface. While strong arguments can be made for a sub-60-V distribution voltage that merits ELV status, energy conservation and higher efficiency may take precedence over the ease of meeting safety agency requirements or the adaptability of reserve systems. Today's low-voltage distribution buses suffer from lower efficiencies because of the additional dc-dc converter required to convert the commercial ac line to the lower distribution-bus potential. However, this deficiency can be overcome by newer topologies that provide a single-stage conversion between commercial power and the low-voltage distribution bus. The result is efficiency levels comparable to those of high-voltage buses.

High-voltage buses require rigorous understanding of safety issues.

Before choosing a distribution-voltage level, designers must address trade-offs in the design of ac-dc front-ends that generate the distribution voltage. The least expensive approach is to use the same kind of bridge-rectifier circuit typically used in an off-line switch-mode power supply *(Fig. 4a)*. Such a rectifier produces a dc voltage in the range of 175 to 380 V, depending on the input commercial power applied. If a voltage doubler is used, the voltage range could be minimized to between 240 and 380 V *(Fig. 4b)*.

These voltages may work in applications in which a high-voltage distribution bus is desirable. Unfortunately, the simple rectifier circuits provide no regulation. Fluctuations in line voltage, or changes in load currents, significantly affect the output voltage. These voltage fluctuations must be handled by the downstream dc-dc converters, which adds complexity and substantial cost. Such fluctuations also would severely limit the potential to add internal battery reserve to the system.

The problem can be eliminated by inserting a dc-dc converter between the rectifier and the distribution bus *(Fig. 4c)*. This converter could be a separate unit or be part of the ac-dc front-end generator. In fact, such a front-end converter is almost mandaory today to reduce the harnonic distortion in the ac utility ine generated by the nonlinear nput characteristics of switchnode rectifiers. Several national gencies harbor concerns about he effects of these harmonic disortions and are preparing stanlards that severely limit the mount of harmonic noise that an be coupled back into the ower line. The most widely disussed standard is IEC 555-2, vhich, while not yet implemented, has significantly affected the lesign of power systems.

To meet the expected limits n harmonic noise, circuits must e added to drastically reduce he harmonics generated by the ower system and, consequenty, provide power-factor correcion. Power-factor correction ffers other advantages, such as lelivering about 30% more ower to system loads from tandard 15- or 20-A convenience outlets in the U.S.

IEC 555-2 has significantly affected the design of power systems.

Today, power-factor correction is typically implemented in a power system in the form of a boost converter. Such a converter provides a stable, constant high-voltage distribution bus of about 400 V. So, in addition to lowering harmonics distortion, this method also reduces the complexity and cost of the downstream dc-dc converters by eliminating input-voltage fluctuations. Safety concerns still have to be addressed and the implications of battery reserve remains a major issue.

Power-factor correction also is incorporated into low-voltage distribution systems. However, using a boost converter requires the additional dc-dc step-down converter to generate the low-voltage bus. Recent inventions for low-voltage distribution buses are looming on the horizon. New circuits are emerging that incorporate power-factor correction and low-voltage conversion into a single power stage.

In summary, it's safe to say that the low-voltage distribution bus has at last reached efficiency parity with its high voltage counterparts. The low-voltage bus also provides significant benefits in system integration, specifically adaptability to reserve systems and ease in system certification.

Gabriel G. Suranyi, power-systems engineer at AT&T Power Systems, holds a BSEE from New York University and an MBA from Stevens Institute of Technology, Hoboken, N.J.

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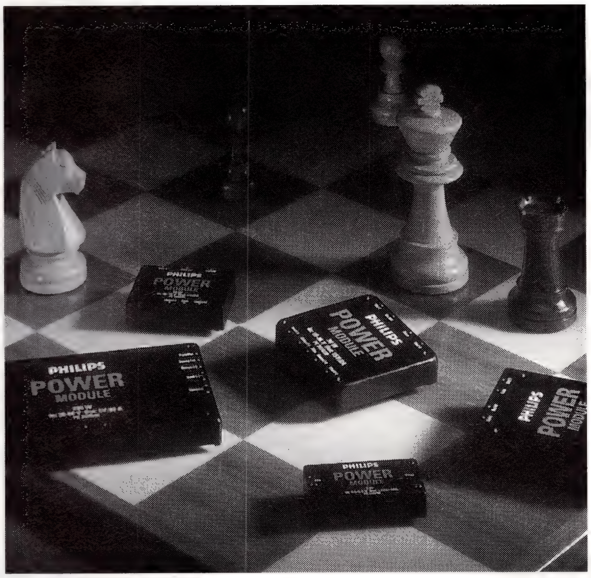

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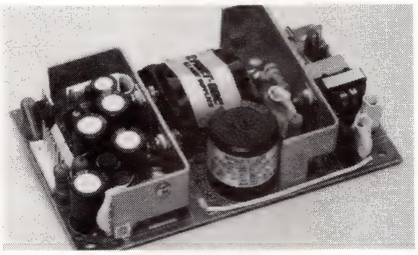

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▼ MOSFET DRIVERS OBVIATE DISCRETES

A cost-effective means of replacing discrete parts in MOSFET-driving applications without sacrificing performance is provided by the TC1410-1413 family of MOSFET drivers. Available in peak output currents of 0.5, 1, 2, and 3 A, the ICs feature a wide operating range of 4.5 to 16 V, short typical delays of 30 ns, and low typical supply currents of 1 mA. Inverting and non-inverting versions are available. Applications include switch-mode power supplies, pulse-transformer drivers, and narrow-pulse processing. In lots of 100, pricing starts at $0.43 for a 0.5-A, 8-pin plastic DIP and tops out at $0.77 for a 3-A driver in an 8-pin SOIC.

TelCom Semiconductor Inc.
1300 Terra Bella Ave.
P.O. Box 7267
Mountain View, CA 94039-7267
(415) 968-9241
▶ CIRCLE 918

POWER-SOURCE MANUFACTURERS

AER Energy Resources
1500 Wilson Way, Suite 250
Smyrna, GA 30082
(404) 433-2127
(ZA)
CIRCLE 700

AT&T
Microelectronics Div.
555 Union Blvd.
Dept. 500404200
Allentown, PA 18103
(800) 372-2447
(500R) (10R) (SW) (MF)
(PI) (PC)
CIRCLE 701

AT&T Microelectronics
Power Systems
3000 Skyline Dr.
Mesquite, TX 75149
(214) 284-3058
(50S) (11S) (200S) (RM)
(OF) (CV) (RP) (PF) (50C)
(11C) (200C) (DC) (MO) (50R)
(11R) (200R) (SW) (MU)
CIRCLE 702

ATC Power Systems
45 Depot St.
Merrimack, NH 03054
(603) 429-0391
(50S) (11S) (200S) (RM) (OF)
(CV) (MD) (PF) (50C) (11C)
(200C) (DC) (MO) (MI)
CIRCLE 703

Abbott Electronics Inc.
2727 S. La Cienega Blvd.
Los Angeles, CA 90034
(310) 202-8820
(50S) (51S) (10S) (11S)
(200S) (OF) (CV) (MD) (PF)
(50C) (51C) (10C) (11C)
(200C) (DC) (AC) (MO) (MI)
(50R) (51R) (500R) (11R)
(200R) (LI) (SW) (MU) (ML)
CIRCLE 704

Absopulse Electronics Ltd.
110 Walgreen Rd.
Carp, Ontario, Canada
K0A 1L0
(613) 836-3511
(50S) (51S) (10S) (11S)
(200S) (LA) (RM) (OF)
(CV) (PF) (UN) (PF)
(50C) (51C) (10C) (11C)
(200C) (DC) (AC) (MO)
CIRCLE 705

Acme Electric Corp.
Electronics Div.
20 Water St.
Cuba, NY 14727
(716) 968-2400
(50S) (200S) (OF) (CV) (UN)
(PF) (50C) (200C) (DC) (50R)
(11R) (200R) (LI) (SW)
CIRCLE 706

Acon Inc.
22 Bristol Dr.
South Easton, MA 02375
(508) 230-8022
(50C) (51C) (DC) (50R)
(51R) (SW)
CIRCLE 707

Acopian
P.O. Box 638
Easton, PA 18044
(610) 258-5441
(50S) (51S) (500S) (10S)
(11S) (200S) (RM) (CV)
(RP) (MD) (50C) (10C)
(11C) (DC) (MO)
CIRCLE 708

Advanced Analog
2270 Martin Ave.
Santa Clara, CA 95050
(408) 988-4930
(50S) (10S) (11S) (MD)
(50C) (DC) (MO) (IC) (MI)
CIRCLE 709

Advanced Power Designs Inc.
17744 Skypark Circle
Suite 250
Irvine, CA 92714
(714) 263-8605
(RP)
CIRCLE 710

Advanced Power Technology
405 S.W. Columbia St.
Bend, OR 97702
(503) 382-8028
(MF) (RE)
CIRCLE 711

Alliant Techsystems
Power Sources Center
104 Rock Rd.
Horsham, PA 19044
(215) 674-3800
(LT)
CIRCLE 712

American Power Conversion
132 Fairgrounds Rd.
West Kingston, RI 02892
(401) 789-5735
(51S) (200S) (RM) (UN)
(51R) (200R) (SW) (LC)
CIRCLE 713

American Reliance Inc.
11801 Goldring Rd.
Arcadia, CA 91106
(800) 654-9838
(50S) (51S) (11S) (200S)
(LA) (RM) (CV) (RP) (PF)
CIRCLE 714

Apex Microtechnology Corp.
5980 N. Shannon Rd.
Tucson, AZ 85741
(602) 690-8600
(50C) (10C) (11C) (DC)
CIRCLE 715

Arnold Magnetics Corp.
4000 Via Pescador
Camarillo, CA 93012
(805) 484-4221
(50S) (51S) (500S) (10S)
(11S) (200S) (RM) (MD) (PF)
(DC) (MO) (MI) (50R) (51R)
(500R) (10R) (11R) (200R)
(LI) (SW) (MU) (ML)
CIRCLE 716

Ascom Warren Inc.
12 Executive Dr.
Hudson, NH 03051
(603) 598-4700
(50S) (RM) (UN) (50C)
(51C) (DC) (AC)
CIRCLE 717

Astec Standard Power
401 Jones Rd.
Oceanside, CA 92054
(619) 757-1880
(50S) (10S) (11S) (200S) (RM)
(OF) (CV) (PR) (PF) (50C)
(10C) (11C) (200C) (DC) (MO)
CIRCLE 718

Astrosystems Inc.
Behlman Electronics
6 Nevada Dr.
Lake Success, NY 11042
(516) 328-1660
(50S) (51S) (11S) (200S)
(LA) (RM) (PR) (RP) (UN)
(PF) (50C) (51C) (11C)
(200C) (AC) (50R) (51R)
(11R) (200R) (LI)
CIRCLE 719

Ault Inc.
7300 Boone Ave. N.
Minneapolis, MN 55428-1028
(612) 493-1900
(50S)
CIRCLE 720

Autec Power Systems
69 Moreland Rd.
Simi Valley, CA 93065
(805) 522-0888
(50S) (OF) (CV) (PF)
(50C) (SW)
CIRCLE 721

Avex Electronics Corp.
Portable Battery Div.
P.O. Box 1026
Bensalem, PA 19020
(800) 345-1295
(AL) (CZ) (LC) (LT) (NC)
(NH) (NM) (ZA) (ZC)
CIRCLE 722

B & K Precision
6470 W. Cortland St.
Chicago, IL 60635
(312) 889-1448
(50S) (51S) (10S) (11S)
(LA) (CV) (PR)
CIRCLE 723

BICC-VERO Electronics Inc.
1000 Sherman Ave.
Hamden, CT 06514
(203) 288-8001
(51S) (500S) (200S)
(RM) (UN)
CIRCLE 724

Basler Electric Co.
Electronic Product Group
Route 143, P.O. Box 269
Highland, IL 62249
(618) 654-2341
(50S) (200S) (RM) (OF) (PF)
CIRCLE 725

(see p. 129 for key)

(continued on p. 116)

POWER-SOURCE MANUFACTURERS

Battery Engineering Inc.
1636 Hyde Park Ave.
Hyde Park, MA 02136
(617) 361-7555
(LT)
CIRCLE 726

Behlman
6 Nevada Dr.
Lake Success, NY 11042
(516) 328-1600
(50S) (51S) (11S) (200S) (LA) (RM) (CV) (PR) (RP) (MD) (UN) (PF) (50R) (51R) (11R) (200R) (LI) (SW) (ML)
CIRCLE 727

Bertan High Voltage
121 New South Rd.
Hicksville, NY 11801
(516) 433-3110
(51S) (500S) (10S) (11S) (200S) (LA) (RM) (OF) (CV) (RP) (51C) (500C) (10C) (11C) (DC) (MO)
CIRCLE 728

Boeing Defense & Space Group
Electronic Systems Div.
P.O. Box 3999, M/S 3F-96
Seattle, WA 98124-2499
(206) 657-4133
(50S) (51S) (RM) (CV) (MD) (PF) (50C) (51C) (10C) (11C) (200C) (DC) (MO) (MI) (50R) (51R) (10R) (11R) (200R) (LI) (SW) (MU) (ML)
CIRCLE 729

Brandt Electronics Inc.
815 E. Middlefield Rd.
Mountain View, CA 94043
(415) 967-4944
(50S) (51S) (500S) (10S) (11S) (200S) (CV) (MD) (PF) (50C) (51C) (500C) (10C) (11C) (200C) (DC) (MI) (50R) (51R) (500R) (10R) (11R) (200R) (LI) (SW) (ML)
CIRCLE 730

Cal-Tek Engineering
DC UPS Div.
P.O. Box 202
Kingston, MA 02364
(617) 585-5666
(50S) (11S) (RM) (UN)
CIRCLE 731

Calex Mfg. Co. Inc.
2401 Stanwell Dr.
Concord, CA 94520-4841
(510) 687-4411
(50S) (10S) (LA) (CV) (50C) (10C) (11C) (DC) (MO)
CIRCLE 732

California Instruments Corp.
9025 Balboa Ave.
San Diego, CA 92123-1509
(800) 422-7693
(50S) (51S) (11S) (200S) (LA) (RM) (OF) (CV) (PR) (RP) (MD) (PF) (50C) (51C) (11C) (200C) (MO) (50R) (51R) (11R) (200R) (LI) (SW)
CIRCLE 733

Caritronics Inc.
P.O. Box 821
West Caldwell, NJ 07007
(201) 575-8916
(50C) (51C) (500C) (10C) (11C) (DC)
CIRCLE 734

Central Semiconductor Corp.
145 Adams Ave.
Hauppauge, NY 11788
(516) 435-1110
(BT) (MF) (RE) (TH)
CIRCLE 735

Cherokee International Inc.
2841 Dow Ave.
Tustin, CA 92680
(714) 544-6665
(50S) (RM) (OF) (CV) (PF) (50C) (11C) (200C) (DC) (MO) (SW) (MU)
CIRCLE 736

Cherry Semiconductor Corp.
2000 S. County Trail
East Greenwich, RI 02818
(401) 886-3895
(50R) (LI) (SW) (PC)
CIRCLE 737

Christie Electric Corp.
18120 S. Broadway
Gardena, CA 90248
(310) 715-1402
(50S) (200S) (LA) (CV) (MD)
CIRCLE 738

Clary Corp.
1960 S. Walker Ave.
Monrovia, CA 91016
(800) 442-5279
(51S) (10S) (11S) (200S) (LA) (RM) (OF) (PR) (MD) (UN) (PF) (51C) (11C) (200C) (AC) (MO) (MI) (51R) (10R) (11R) (200R) (SW) (ML) (LC) (MF)
CIRCLE 739

Computer Products Inc.
Power Conversion America
7 Elkins St.
Boston, MA 02127
(617) 464-6656
(50S) (51S) (10S) (11S) (200S) (OF) (CV) (RP) (PF) (50C) (51C) (10C) (11C) (200C) (DC) (MO) (IC) (50R) (10R) (11R) (200R) (LI) (SW) (MU) (ID)
CIRCLE 740

Contact East Inc.
335 Willow St.
North Andover, MA 01845
(508) 682-2000
(50S) (LA) (RM) (CV) (UN) (LI) (SW) (AL) (LT) (ME) (NC)
CIRCLE 741

Controlled Power Co.
1955 Stephenson Hwy.
Troy, MI 48083
(800) 521-4792
(51S) (500S) (200S) (LA) (RM) (CV) (PR) (MD) (UN) (PF) (51C) (200C) (DC) (AC) (MO) (MI) (51R) (500R) (200R)
CIRCLE 742

Conversion Devices Inc.
15 Jonathan Dr.
Brockton, MA 02401
(508) 559-0880
(50S) (10S) (11S) (MD) (50C) (10C) (11C) (DC) (MO) (IC) (MI)
CIRCLE 743

Crydom Co.
6015 Obispo Ave.
Long Beach, CA 90805
(310) 865-3536
(RE) (TH)
CIRCLE 744

Custom Power Systems
33 Comac Loop
Ronkonkoma, NY 11779
(516) 467-5328
(50S) (51S) (10S) (11S) (200S) (LA) (RM) (OF) (CV) (RP) (MD) (UN) (PF) (50C) (51C) (10C) (11C) (200C) (DC) (AC) (MO) (IC) (MI) (50R) (51R) (10R) (11R) (200R) (LI) (SW) (MU) (ID) (ML)
CIRCLE 745

D&B Power Inc.
204 N. Fehr Way
Bayshore, NY 11706
(516) 586-5955
(50S) (11S) (OF) (CV) (MD) (50C) (11C) (50R) (11R) (LI)
CIRCLE 746

Datel Inc.
11 Cabot Blvd.
Mansfield, MA 02172
(508) 339-3000
(50C) (DC) (MO)
CIRCLE 747

Del Electronics Corp.
Power Conversion Div.
One Commerce Park
Valhalla, NY 10595
(914) 686-3600
(500S) (10S) (11S) (200S) (LA) (RM) (CV) (RP) (MD) (500C) (10C) (11C) (200C) (DC) (MO) (MI)
CIRCLE 748

Delta Products Corp.
3225 Laurelview Ct.
Fremont, CA 94538
(510) 770-0660
(50S) (51S) (10S) (11S) (200S) (RM) (OF) (PF) (50C) (10C) (11C) (DC) (AC) (50R) (10R) (11R) (200R) (SW)
CIRCLE 749

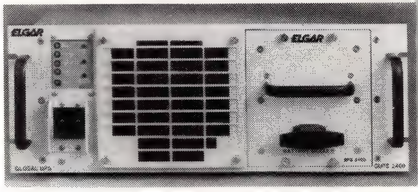
Deltec Electronics Corp.
2727 Kurtz St.
San Diego, CA 92110
(619) 291-4211
(UN)
CIRCLE 750

Deltron Inc.
P.O. Box 1369
290 Wissahickon Ave.
North Wales, PA 19454
(215) 699-9261
(50S) (11S) (200S) (OF) (PF)
CIRCLE 751

(see p. 129 for key)
(continued on p. 118)

▼ RUGGED UPS TAKES U.S. POWER WORLDWIDE

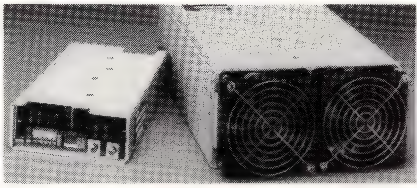
From various input voltages anywhere in the world, the GUPS 2400U global uninterruptible power system provides 2400 VA of clean, continuous power at either 115 V/60 Hz or 230 V/50 Hz (switchable). The compact, on-line unit protects critical computer-based systems from fluctuating voltages or frequencies, spikes, sags, surges, and brownouts which otherwise would cause system crashes or data loss. Any available ac-power input from 85 to 280 V and from 45 to 450 Hz is acceptable. A drawer-mounted battery module provides service for up to 5 minutes at full load at 25°C. Pricing is $8750 in singles with 60-day delivery.



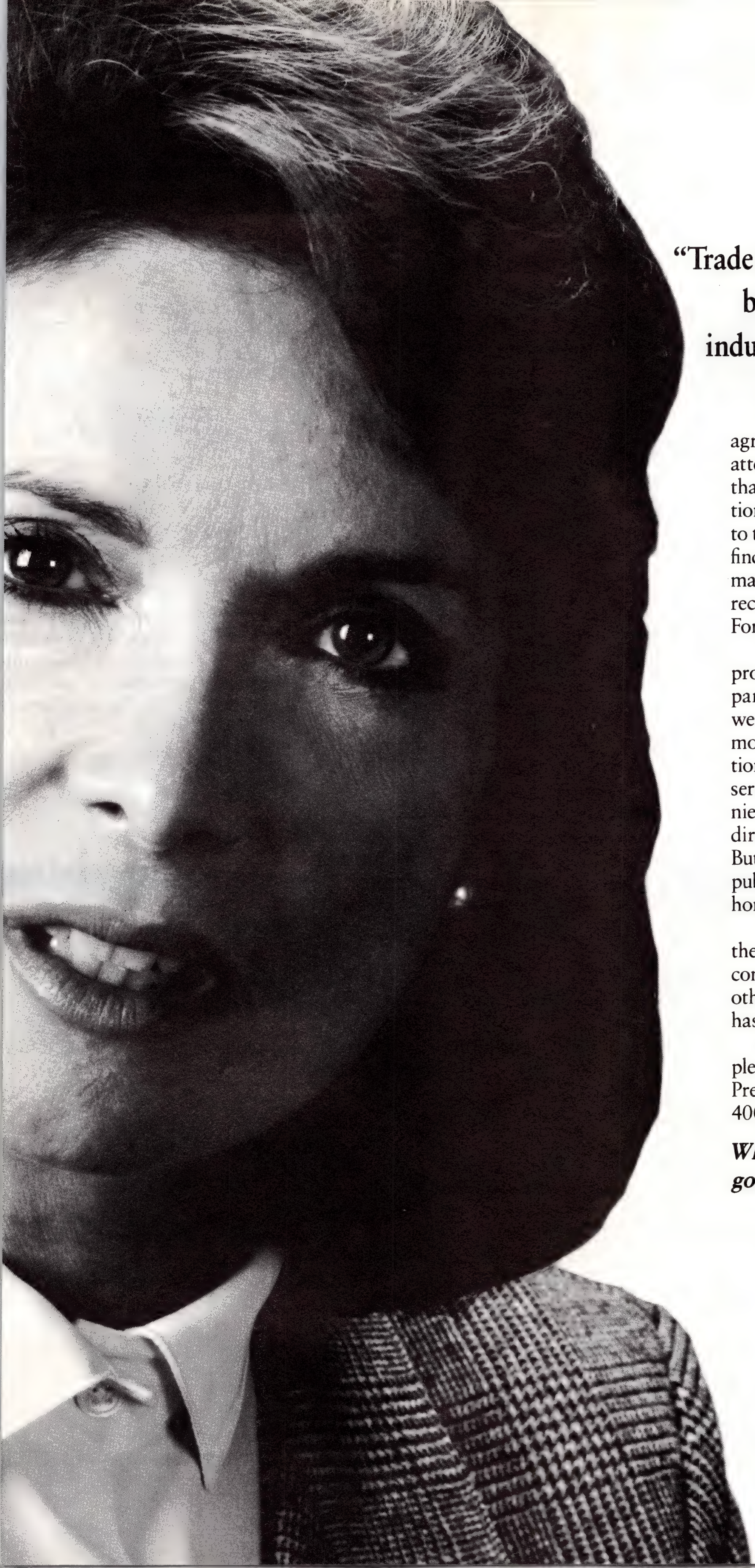
Elgar Corp.
9250 Brown Deer Rd.
San Diego, CA 92121
(619) 450-0085
▶CIRCLE 919

▼ SWITCHING SUPPLIES GETTING SMALLER

To meet OEM demand for power supplies with more performance and reliability in less space, the NMX Series takes full advantage of surface-mount construction. The single- and multiple-output supplies have fewer through-hole components, a smaller footprint, and a lower profile than their predecessors. For example, the 350-W NMX-350 occupies just 66.5 in.^{3} compared with Todd's MAX-350, which took up 112.5 in.^{3}. A 1500-W model, the NMX-1500, is also offered. Call for pricing and delivery information.



Todd Products Corp.
50 Emjay Blvd.
Brentwood, NY 11717
(516) 231-3366
▶CIRCLE 920



"Trade shows are valuable, but I learn more from my industry publications."

Your customers and prospects agree that trade shows are worth attending. But they also agree that specialized business publications are worth a great deal more to them. Because that's where they find more of the important information they need to know. A recent study, conducted by the Forsyth Group, proves it.

Almost 10,000 business and professional decision makers participated in the study. They were asked what sources they find most useful in providing information about the products and services they buy for their companies. Trade shows, salespeople and direct mail were all well regarded. But overall, specialized business publications clearly took top honors.

Trade magazines are also at the top of the list when you consider cost per contact. No other medium is more efficient. Or has more credibility.

For a free copy of the study, please write to American Business Press, 675 Third Avenue, Suite 400, New York, NY 10017.

Where business goes shopping. ABP

POWER-SOURCE MANUFACTURERS

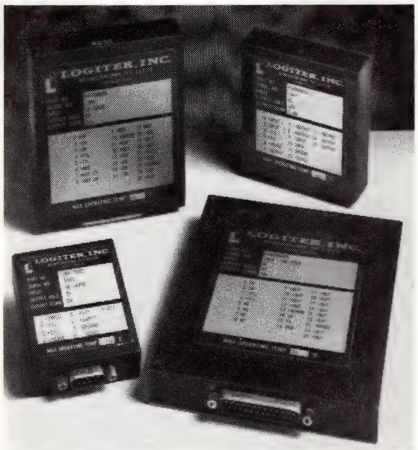
▼ DC-DC CONVERTERS BOAST EFFICIENCY

Efficiencies of 82.5% typical and power densities of 33 W/in.^{3} are featured in the FE200 Series power modules. The 200-W units accept inputs from 38 to 60 V dc and provide precisely regulated and fully isolated voltages than can be trimmed up or down by 10%. A full feature set includes complete input and output filtering, remote sense and on/off, short-circuit protection, an output-overvoltage clamp, current limiting, and thermal shutdown. The unit falls within FCC requirements for telecommunication applications and meets UL, CSA, and TUV standards. Applications include redundant and distributed-power architectures, PBXs, and other telecom tasks. Pricing is as low as $147 for lots from 500 to 999. Small quantities are delivered from stock.

AT&T Microelectronics
Dept. AL-500404200
555 Union Blvd.
Allentown, PA 18103
(800) 372-2447
▶CIRCLE 921

▼ AC-DC SWITCHERS INCLUDE FILTERING

EMI filtering to MIL-STD-461C specs is built into a line of universal-input ac-dc switching power supplies. The compact supplies come in ratings from 25 to 300 W and in single- to quad-output configurations. Outputs are from 3.3 to 48 V to meet a variety of low- and medium-powe requirements. In addition to minimizing the need for external EMI filters, the supplies save space and reduce design and component costs Pricing starts at $700 with availability in six to eight weeks.



Logitek Inc.
101 Christopher St.
Ronkonkoma, NY 11779-6922
(516) 467-4200
▶CIRCLE 922

▼ 400-, 500-W SUPPLIES INCLUDE TOP-MOUNT FAN

A compact, low-profile case with a top-mounted fan for efficient cooling houses the XM Series of 400- and 500-W switching power supplies. Single and multiple-output models are offered with up to four total outputs The basic case size is 2.16 by 5 by 8 in with 1 in. added to the height by the fan. Main outputs are 5 V dc at either 60 or 70 A. Up to three auxiliary outputs can be configured to specification. Pricing in OEM lots starts at $298. Samples ship in two weeks

Unipower Corp.
3900 Coral Ridge Dr.
Coral Springs, FL 33065
(305) 346-2442
▶CIRCLE 923

POWER-SOURCE MANUFACTURERS

Digital Data Systems Inc.
1551 N.W. 65th Ave.
Ft. Lauderdale, FL 33313
(305) 792-3290
(50S) (RM) (OF) (MD)
(UN) (50C) (DC) (MI)
CIRCLE 752

Digital Power Corp.
41920 Christy St.
Fremont, CA 94538-3158
(510) 657-2635
(50S) (11S) (200S) (OF)
(RP) (PF) (50C) (11C)
(200C) (DC) (SW)
CIRCLE 753

Duracell Inc.
New Products
& Technology
Berkshire Corporate Park
Bethel, CT 06801
(800) 544-5454
(AL) (LT) (NM) (ZA)
CIRCLE 754

EFI Electronics Corp.
Industrial Products Div.
2415 South 2300 West
Salt Lake City, UT 84119
(801) 977-9009
(200S) (UN)
CIRCLE 755

EG&G Power Systems
1330 E. Cypress St.
Covina, CA 91724
(818) 967-9521
(50S) (51S) (11S) (200S)
(MD) (PF) (50C) (51C) (11C)
(200C) (DC) (MO) (MI) (50R)
(51C) (11R) (200R) (SW)
(MU) (ML)
CIRCLE 756

EMCO
Component Specialties Div.
1172 Route 109
Lindenhurst, NY 11757
(516) 957-8700
(50S) (LA) (50C) (AC)
CIRCLE 757

EPE Technologies
Subsidiary of Square D
1660 Scenic Ave.
Costa Mesa, CA 92626
(714) 557-1636
(200S) (RM) (UN) (PF)
CIRCLE 758

Eagle Picher Industries Inc.
Commercial Products Dept.
P.O. Box 130
Seneca, MO 64865
(417) 776-2256
(UN) (LC) (LT) (NH)
CIRCLE 759

Eagle-Picher Industries Inc.
Electronics Div.
C & Porter Sts., P.O. Box 47
Joplin, MO 64802
(417) 623-8000
(MD) (UN) (LC) (LT) (NC)
(NH) (NM) (SO) (ZA)
CIRCLE 760

East Penn Mfg. Co. Inc.
Deka Road
Lyon Station, PA 19536
(619) 682-6361
(LC)
CIRCLE 761

Edal Industries Inc.
4 Short Beach Rd.
East Haven, CT 06512
(203) 467-2591
(RE)
CIRCLE 762

Electroid Co.
45 Fadem Rd.
Springfield, NJ 07081
(201) 467-8100
(50S)
CIRCLE 763

Electronic Measurements Inc.
405 Essex Rd.
Neptune, NJ 07753
(908) 922-9300
(200S) (LA) (RM) (CV)
(RP) (PF) (11C) (200C)
(DC) (AC) (LI) (SW) (MU)
CIRCLE 764

Elenco Electronics Inc.
150 W. Carpenter St.
Wheeling, IL 60090
(708) 541-3800
(50S) (LA)
CIRCLE 765

Elgar Corp.
9250 Brown Deer Rd.
San Diego, CA 92121
(619) 450-0085
(51S) (200S) (LA) (RM)
(PR) (RP) (51C) (200C)
(MO) (51R) (200R) (LI)
CIRCLE 766

Elpac Power Systems
6527 Paseo Diego
Anaheim, CA 92714
(714) 476-6070
(50S)
CIRCLE 767

Energizer Power Systems
P.O. Box 147114
U.S. Hwy. 441 N.
Gainesville, FL 32614-7114
(904) 462-4726
(AL) (CZ) (LT) (ME) (NC)
(MN) (SO) (ZA) (ZC)
CIRCLE 768

Engineered Magnetics Inc.
18435 Susana Rd.
Rancho Dominquez, CA
90221
(310) 635-9555
(50S) (51S) (11S) (200S)
(RM) (CV) (PR) (MD) (PF)
(50C) (51C) (11C) (200C)
(DC) (AC) (MI) (50R) (51R)
(11R) (200R) (SW) (ML)
CIRCLE 769

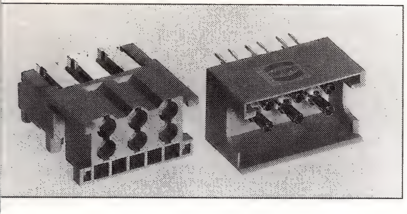
Entran Devices Inc.
10 Washington Ave.
Fairfield, NJ 07004
(201) 227-1002
(50S)
CIRCLE 770

Ericsson Components Inc.
Power Products Group
403 International Pkwy.
Richardson, TX 75081
(214) 997-6561
(50C) (51C) (10C)
(11C) (DC) (MO)
CIRCLE 771

(see p. 129 for key)

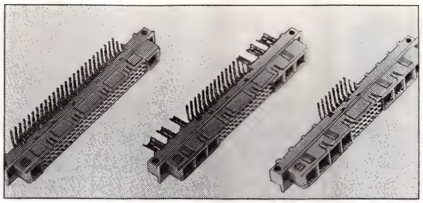
(continued on p. 120)

EW HIGH DENSITY ICRO-COAXIAL CONTACTS



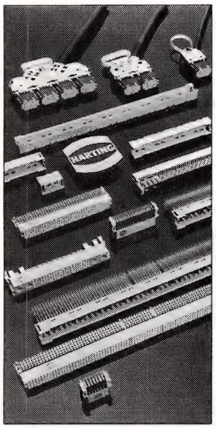
esigned for high speed data transfer tes. Can be used in the IEC 1076-4-2 5mm High Density connector sys- m,har-pak ®. Provides more space effi- ency, high frequency capability, easy andling, low applied cost and applica- on with current equipment practice and merging metric equipment practices. esigned for PCB termination on both aughtercard to backplane connec- on;allowing users to bring signal directly o the backplane without a cable transition.

EADER SERVICE 88



COMPLIANT PIN DIN 41612-TYPE M INVERSE CONNECTORS

HARTING'S compliant pin Inverse Type M DIN 41612 Eurocard connectors allow continued development of backplane technology using solderless termination and double-side surface mounting. Applications include telecom, medical and high speed computers. Connector-cavities accommodate the DIN 41626 high voltage, power, coaxial or fiber optic contacts. Connector arrangements can accommodate 2 to 10 special purpose contacts and 78 to 6 standard contacts respectively.Compatible with HARTING male press-in tooling without modification, it can be delivered with special press-in inserts to allow use of 'Flat Rock" or simple flatpress-in dies. **READER SERVICE 89**



har-pak® 2.5 MM High Density Connector system

Developed for backplane and daughterboard applications in modern rack systems. The 5 row 2.5 mm connector design offers solderless PCB terminations, optimum utilization of space, three dimensional modularity, high contact density, EMI protection, and the ability to double-side surface mount components on daughter cards without loss of a 15 mm card pitch. The har-pak connector system permits using a three dimensional 2.5 mm grid. With the exceptional capabilites of the connector, only one connector style is required to solve your power, signal, ground, and high data rates; simplifying the design and manufacturing of future systems.The compliant pin technology utilizes the same 1 mm plated through hole standard for many DIN 41 612 compliant pin technologies. The consistency in design uses the many years of manufacturing and design experience already available.These attributes combined can lead to new advancements n board-level designs: 15 mm card pitch with double-sided surface mounted daughter cards, butterfly or mid-plane techniques, modular design both horizontally and vertically,low number of system components, combination with other standardized packaging systems,and lower applied costs.

READER SERVICE 90

'har-mik®', NEW MINATURE CONNECTORS FROM HARTING ELEKTRONIK

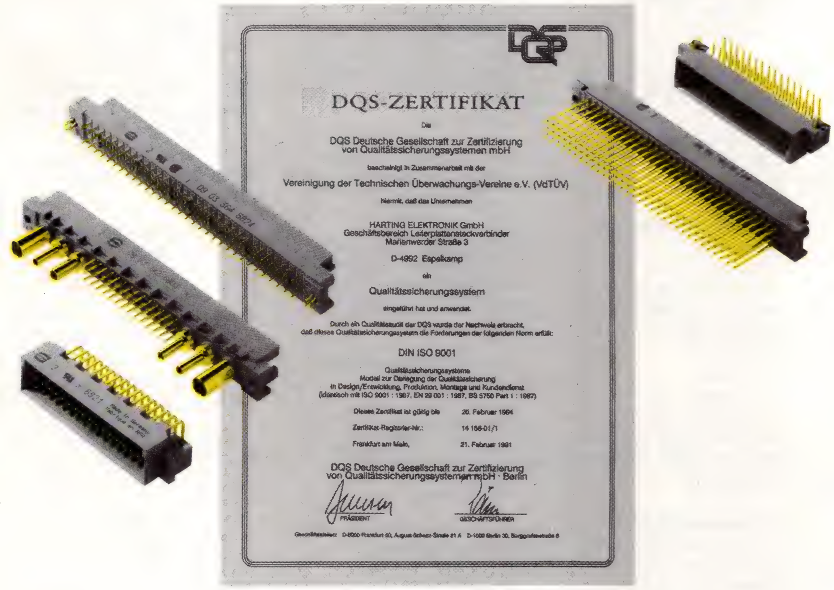
New, comprehensive range of miniature connectors, the 'Pin and Socket' I/0 connectors Series 60.01/02/03/04, are designed to meet the requirements of internal and external connections of the future.

- Reduced size: contact pitch of 1,27 mm
- High contact density: double standard D-Sub
- E.M.I./R.F.I. protected. metal shells and hoods for optimum screening
- Polarized by D shape
- Coding: without contact loss
- Locking device: quick latch for S.C.S.I/RS 232 E applications. Jackscrew for I.P.I/HI.P.P.I applications
- Male and female IDC versions for discrete wire 28 to 30 AWG
- Male and female connectors with straight and angled solder pins
- Many connector sizes: from 20 to 100 ways

READER SERVICE 91

DIN connectors

The Oscar for quality



DQS-ZERTIFIKAT

Die

DQS Deutsche Gesellschaft zur Zertifizierung
von Qualitätssicherungssystemen mbH

bescheinigt in Zusammenarbeit mit der

Vereinigung der Technischen Überwachungs-Vereine e.V. (VdTÜV)

hiermit, daß das Unternehmen

HARTING ELEKTRONIK GmbH
Geschäftsbereich Leiterplattensteckverbinder
Marienwerder Straße 3

D-4992 Espelkamp

ein

Qualitätssicherungssystem

eingeführt hat und anwendet.

Durch ein Qualitätsaudit der DQS wurde der Nachweis erbracht,
daß dieses Qualitätssicherungssystem die Forderungen der folgenden Norm erfüllt:

DIN ISO 9001

Qualitätssicherungssysteme
Modell zur Darlegung der Qualitätssicherung
in Design/Entwicklung, Produktion, Montage und Kundendienst
(identisch mit ISO 9001 : 1987, EN 29 001 : 1987, BS 5750 Part 1 : 1987)

Dieses Zertifikat ist gültig bis 20. Februar 1994

Zertifikat-Registrier-Nr.: 14 156-01/1

Frankfurt am Main, 21. Februar 1991

DQS Deutsche Gesellschaft zur Zertifizierung
von Qualitätssicherungssystemen mbH · Berlin

PRÄSIDENT GESCHÄFTSFÜHRER

Geschäftsstellen: D-6000 Frankfurt 60, August-Schanz-Straße 21 A D-1000 Berlin 30, Burggrafenstraße 6

DQS, the German QA System Certification Company, has awarded our PCB Connector Division the DIN ISO 9001 Certificate. This confirms our efforts to achieve perfection in both products and manufacturing methods.

HARTING is one of the first connector manufacturers in the world to be awarded this internationally recognised certificate of approval.

HARTING's worldwide recognition as a major connector manufacturer is founded not only on state-of-the-art production facilities, but also on an optimal system of quality assurance.

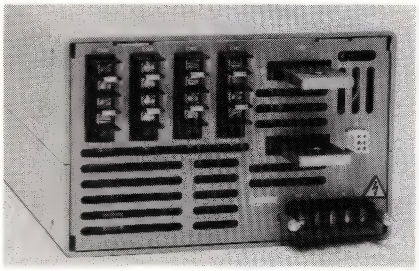
Connectors from HARTING – the quality connection

HARTING ®

WÄCHTER BREMEN

HARTING ELEKTRONIK, Inc. · 2155 Stonington Ave. · Suite 212
P. O. Box 95710 Hoffman Estates, Illinois 60195, U.S.A.
Phone 708 / 519 - 7700 · Fax 708 / 519 - 9771 **READER SERVICE 87**

▼ 1000-W SWITCHER OFFERS PFC, WIDE INPUT



Power-factor correction to 0.99 with a 1000-W load and 120-V ac, 15-A service is provided by the Series 31 switching power supply. Units come with from one to nine outputs. A typical 1000-W, multiple-output model has a 5-V at 150-A main output and three, four, or five auxiliary outputs ranging from 5 to 15 V at 20 A and 5 to 24 V at 10 A. Line regulation is 0.2% and load regulation is 0.8% of rated output voltage. Output ripple and noise is 1% pk-pk at 50 MHz bandwidth. Pricing in OEM lots runs from $731 to $909 with delivery in six to eight weeks.

Lambda Qualidyne Inc.
3055 Del Sol Blvd.
San Diego, CA 92154
(619) 575-1100
▶CIRCLE 924

▼ LDO REGULATOR BOASTS DUAL OUTPUT

Control of two supply voltages for powering analog and digital functions in a single module or system is provided by the CS-8156, a dual 12-V/5-V output, low-dropout linear regulator. Designed for harsh automotive environments, the device is full fault protected with on-board reverse-battery, load-dump, reverse transient, short-circuit, and therma shutdown protection. Also feature is an Enable function to control th output stage, extremely low curren drain (200 nA) in sleep mode, and output accuracy of 2%. In a 5-lead TO 220 package, the device goes fo $1.18 in lots of 10,000. Small quantities are delivered from stock. Call o write for data sheets.

Cherry Semiconductor Corp.
2000 S. County Trail
E. Greenwich, RI 02818
(800) 272-3601
▶CIRCLE 925

POWER-SOURCE MANUFACTURERS

Eveready Battery
Energizer Power Systems
P.O. Box 147114
Gainesville, FL 32614-7114
(904) 462-3911
(AL) (CZ) (LT) (ME) (NC)
(NM) (SO) (ZA) (ZC)
CIRCLE 772

Fedco Electronics Inc.
P.O. Box 1403
Fond Du Lac, WI 54936
(800) 542-9761
(AL) (CZ) (LC) (LT) (ME)
(NC) (NM)
CIRCLE 773

Fluke Corp.
Diagnostic Tools Div.
6920 Seaway Blvd.
Everett, WA 98203
(206) 356-6459
(51S) (11S) (LA) (RM)
(CV) (RP)
CIRCLE 774

Fortron/Source Corp.
2925 Bayview Dr.
Fremont, CA 94538
(510) 440-0188
(50S) (11S) (200S) (OF) (50C)
(10C) (DC) (AC) (LI) (SW)
CIRCLE 775

Gamma High Voltage Research
1096 North U.S. Hwy. 1
Ormond Beach, FL 32174
(904) 677-7070
(51S) (500S) (10S) (11S)
(200S) (LA) (RM) (CV) (RP)
(51C) (500C) (10C) (11C)
(200C) (DC) (MO)
CIRCLE 776

Gates Energy Products Inc.
Industrial Battery Div.
617 North Ridgeview Dr.
Warrensburg, MO 64093-9301
(816) 429-2165
(LC)
CIRCLE 777

Glassman High Voltage
P.O. Box 551
Whitehouse Station, NJ 08889
(908) 534-9007
(500S) (200S) (LA) (RM)
(CV) (RP) (PF)
CIRCLE 778

Golden Systems Inc.
2125-B Madera Rd.
Simi Valley, CA 93065
(805) 582-4417
(50S) (10S) (11S) (200S) (OF)
CIRCLE 779

HC Power Inc.
17032 Armstrong Ave.
Irvine, CA 92714-5716
(714) 261-2200
(50S) (200S) (LA) (RM) (CV)
(PR) (RP) (MD) (PF) (50C)
(200C) (DC) (AC) (50R)
(200R) (SW) (MU) (ML)
CIRCLE 780

Harris Semiconductor
Semiconductor Products
P.O. Box 883
Melbourne, FL 32902
(407) 724-3802
(BT) (MF) (RE) (TH) (PI) (PC)
CIRCLE 781

Hawker Energy Products
4318 Rainbow Blvd.
Suite 730
Kansas City, KS 66103
(800) 730-7733
(LC)
CIRCLE 782

Hewlett-Packard Co.
Direct Marketing Organization
P.O. Box 58059, M/S 51L-SJ
Santa Clara, CA 95051-8059
(800) 452-4844
(50S) (51S) (500S) (10S)
(11S) (200S) (LA) (RM)
(CV) (RP)
CIRCLE 783

Hitran Corp.
362 Hwy. 31
Flemington, NJ 08822
(908) 782-5525
(200) (CV) (LI)
CIRCLE 784

Hydrocap Corp.
975 N.W. 95th St.
Miami, FL 33150-2095
(305) 696-2504
(LC) (NC)
CIRCLE 785

ILC Data Device Corp.
105 Wilbur Pl.
Bohemia, NY 11716
(516) 567-5600
(50C) (11C) (DC) (MO) (MI)
CIRCLE 786

IXYS Corp.
3540 Bassett St.
Santa Clara, CA 95054
(408) 982-0700
(BT) (MF) (RE) (TH) (PI) (PC)
CIRCLE 787

International Power
DC Power Supplies Inc.
360 Bernoulli Cir.
Oxnard, CA 93030-5167
(800) 845-5386
(50S) (51S) (10S) (11S)
(200S) (RM) (OF) (50R) (51R)
(10R) (11R) (200R) (LI)
CIRCLE 788

International Power Devices
20 Linden St.
Boston, MA 02134
(617) 782-3331
(50C) (51C) (10C) (11C)
(200C) (DC) (MO) (IC)
CIRCLE 789

International Power Sources
200 Butterfield Dr.
Ashland, MA 01721
(508) 881-7434
(50S) (OF) (50C) (DC)
(MO) (IC)
CIRCLE 790

Interpoint Corp.
Power Products Div.
10301 Willow Rd.
Redmond, WA 98052
(206) 882-3100
(50S) (51S) (10S) (11S)
(200S) (CV) (MD) (UN) (PF)
(50C) (51C) (10C) (11C)
(200C) (DC) (MO) (IC) (MI)
CIRCLE 791

James Electronics Inc.
4050 N. Rockwell St.
Chicago, IL 60618
(312) 463-6500
(50S) (10S) (11S) (200S) (RM)
(OF) (CV) (UN) (50C) (DC)
(AC) (MO) (50R) (10R) (11R)
(200R) (LI) (SW) (MU)
CIRCLE 792

Jerome Industries Corp.
730 Division St.
Elizabeth, NJ 07201
(908) 353-5700
(50S) (10S) (OF) (CV)
(UN) (10C) (DC)
CIRCLE 793

Jeta Power Systems Inc.
2675 Junipero Ave.
Signal Hill, CA 90806
(310) 427-0095
(50S) (200S) (CV) (PF)
(200C) (DC) (200R) (SW)
CIRCLE 794

K&M Electronics Inc.
11 Interstate Dr.
West Springfield, MA 01089
(413) 781-1350
(500S) (10S) (CV) (RP) (MD)
(500C) (10C) (DC) (MI)
CIRCLE 795

KGS Electronics
A Gar Enterprise Co.
418 E. Live Oak Ave.
Arcadia, CA 91106-5690
(818) 574-1175
(50S) (51S) (10S) (11S)
(200S) (LA) (RM) (CV)
(RP) (MD) (UN) (PF) (50C)
(51C) (10C) (11C) (200C)
(DC) (AC) (MO) (MI) (50R)
(51R) (10R) (11R) (200R)
(LI) (SW) (MU) (ML)
CIRCLE 796

Kepco Inc.
131-38 Sanford Ave.
Flushing, NY 11352
(718) 461-7000
(50S) (51S) (500S) (10S)
(11S) (200S) (LA) (RM) (OF)
(CV) (RP) (PF) (50C) (10C)
(11C) (200C) (DC) (MO)
(50R) (LI) (SW) (MU)
CIRCLE 797

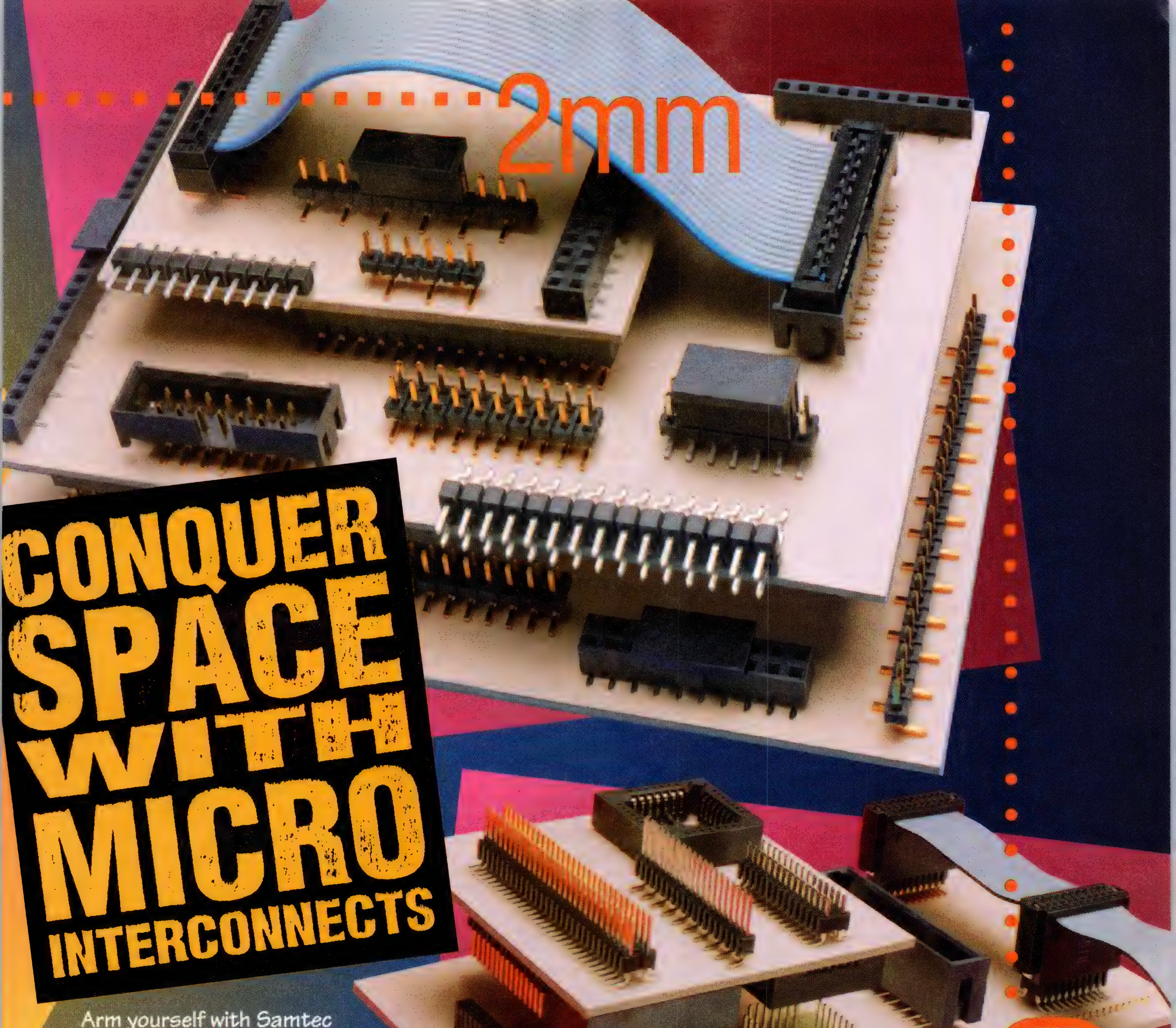
Kikusui International Corp.
1980 Orizaba Ave.
Signal Hill, CA 90804-1203
(310) 986-1677
(50S) (51S) (500S) (10S)
(11S) (200S) (LA) (RM) (CV)
(PR) (RP) (50R) (51R) (500R)
(10R) (11R) (200R) (LI) (SW)
CIRCLE 798

LH Research Inc.
14402 Franklin Ave.
Tustin, CA 92680
(714) 730-0162
(50S) (11S) (200S) (OF)
(CV) (RP) (UN) (PF) (50C)
(11C) (200C) (DC) (MO)
(50R) (11R) (200R) (SW)
CIRCLE 799

LZR Electronics Inc.
8051 Cessna Ave.
Gaithersburg, MD 20879
(301) 921-4600
(50S) (51S) (LA) (OF) (CV)
(PR) (50C) (51C) (DC) (AC)
CIRCLE 800

Lambda Electronics Inc.
515 Broad Hollow Rd.
Melville, NY 11747-3700
(516) 694-4200
(50S) (51S) (10S) (11S)
(200S) (LA) (RM) (OF) (CV)
(RP) (MD) (UN) (PF) (50C)
(51C) (10C) (11C) (200C)
(DC) (MO) (MI)
CIRCLE 801

(see p. 129 for key)
(continued on p. 122)



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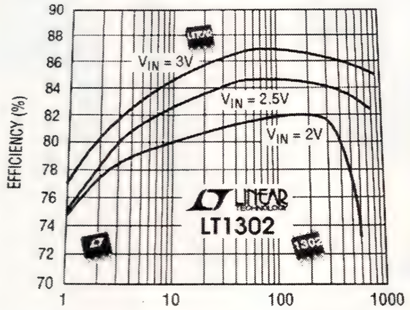
READER SERVICE 194

▼ EFFICIENT CONVERTER PROVIDES 600 mA AT 5 V

An output of 5 V at currents up to 600 mA are provided from a two-cell input by the LT1302 dc-dc converter. Quiescent current for the device is just 200 μA and can be reduced to 15 μA by means of logic-controlled shutdown. The converter maintains high efficiency over a wide range of output current by automatically shifting from burst-mode operation at light loads to current-mode operation under heavier loads. It incorporates an on-chip, low-loss NPN power switch that handles currents of over 2 A and can switch at frequencies up to 400 kHz. Pricing in 8-pin plastic packages is $3.21 for DIPs and $3.35 for SOICs, both in lots of 1000.



Linear Technology Corp.
1630 McCarthy Blvd.
Milpitas, CA 95035-7487
(800) 4-LINEAR
▶ **CIRCLE 926**

▼ FLAT-PACK BATTERY PROFFERS LONG LIFE

Limited-space applications in laptops and other portables are suited for the XPE-50730-F3X rechargeable lead-acid flat battery pack. The unit is rated at 6 V dc at 3 Ah and operates in any orientation. Cycle life is 400 to 500 cycles at 100% discharge, 800 to 1000 cycles at 50% discharge, and 1700 to 2000 cycles at 30% discharge. A 95% recharge is attained in just one hour with a controlled charger and a 100% recharge takes just three hours with a constant-voltage charger. The battery measures 7-15/16 in. long, 4-1/16 in. high, and 11/32 in. thick and weighs 15.2 ozs. Pricing is $32.75 in lots of one to 10.

Tauber Electronics Inc.
4901 Morena Blvd., Suite 314
San Diego, CA 92117
(619) 274-7242
▶ **CIRCLE 927**

POWER-SOURCE MANUFACTURERS

Lambda Novatronics Inc.
500 S.W. 12th Ave.
P.O. Box 878
Pompano Beach, FL 33061
(305) 784-2477
(50S) (51S) (500S) (11S)
(200S) (RM) (OF) (CV) (MD)
(PF) (50C) (51C) (500C) (11C)
(200C) (DC) (MO) (MI) (50R)
(51R) (500R) (11R) (200R)
(SW) (MU) (ML)
CIRCLE 802

Lambda Qualidyne Inc.
3055 Del Sol Blvd.
San Diego, CA 92154
(619) 575-1100
(50S) (51S) (11S) (200S) (RM)
(OF) (CV) (RP) (UN) (PF)
(50C) (51C) (11C) (200C)
(DC) (AC) (MO) (50R) (51R)
(11R) (200R) (SW) (MU)
CIRCLE 803

Lamp Technology Inc.
1645 Sycamore Ave.
Bohemia, NY 11716
(516) 567-1800
(AL)
CIRCLE 804

Liebert Corp.
1050 Dearborn Dr.
Columbus, OH 43229
(614) 888-0246
(51S) (500S) (11S) (200S)
(LA) (RM) (OF) (CV) (PR)
(RP) (MD) (UN) (PF) (51C)
(500C) (11C) (200C) (AC)
(MO) (MI) (51R) (500R) (11R)
(200R) (LI) (SW) (MU) (ML)
CIRCLE 805

Linear Technology Corp.
1630 McCarthy Blvd.
Milpitas, CA 95035
(408) 432-1900
(50C) (51C) (10C) (11C)
(200C) (DC) (IC) (MI) (50R)
(10R) (11R) (200R) (LI) (SW)
(ID) (ML) (PI) (PC)
CIRCLE 806

Logitek Inc.
101 Christopher St.
Ronkonkoma, NY 11779-6922
(516) 467-4200
(50S) (11S) (200S) (RM) (MD)
(PF) (50C) (11C) (200C) (DC)
(AC) (MO) (MI)
CIRCLE 807

Lutze Inc.
1911-A Associates Ln.
Charlotte, NC 28217
(704) 357-8835
(50S) (OF) (CV) (UN) (DC)
(AC) (MO)
CIRCLE 808

MIL Electronics Inc.
One Chestnut St.
Nashua, NH 03063
(603) 882-3200
(50S) (51S) (500S) (10S)
(11S) (CV) (RP) (MD) (50C)
(51C) (500C) (10C) (11C)
(DC) (MO) (MI) (50R) (51R)
(500R) (10R) (11R) (LI)
(SW) (MU) (ML)
CIRCLE 809

Maxim Integrated Products
120 San Gabriel Dr.
Sunnyvale, CA 94086
(408) 737-7600
(50S) (50C) (DC) (50R)
(LI) (SW) (ID) (ML)
CIRCLE 810

Melcher Inc.
187 Billerica Rd.
Chelmsford, MA 01824
(508) 256-1812
(50S) (RM) (RP) (MD)
(PF) (50C) (10C) (11C)
(200C) (DC) (MO) (IC) (MI)
(50R) (10R) (11R) (200R)
(SW) (ID) (ML)
CIRCLE 811

Micrel Semiconductor
1849 Fortune Dr.
San Jose, CA 95131
(408) 944-0800
(50R) (LI) (SW) (ID)
(MF) (PI) (PC)
CIRCLE 812

Micro Energy Inc.
Development Center
745 W. State Rd., 434
Longwood, FL 32750-4909
(708) 501-5000
(50S) (11S) (200S) (OF)
(CV) (PF) (50C) (10C)
(11C) (DC) (50R) (10R)
(11R) (200R) (SW)
CIRCLE 813

Micro Linear Corp.
2092 Concourse Dr.
San Jose, CA 95131
(408) 433-5200
(50C) (51C) (500C) (10C)
(11C) (200C) (DC) (IC)
(50R) (51R) (500R) (10R)
(11R) (200R) (LI) (SW)
(ID) (PI) (PC)
CIRCLE 814

Modular Devices Inc.
4115 Spencer St.
Torrance, CA 90503
(310) 542-8561
(50S) (11S) (200S) (RM)
(OF) (RP) (UN) (PF) (50C)
(11C) (200C) (DC)
CIRCLE 815

Modular Devices Inc.
One Roned Rd.
Brookhaven R&D Pl.
Shirley, NY 11967
(516) 345-3100
(50S) (51S) (500S) (10S)
(11S) (200S) (RM) (OF) (CV)
(PR) (RP) (MD) (UN) (PF)
(50C) (51C) (500C) (10C)
(11C) (200C) (DC) (AC) (MO)
(IC) (MI) (50R) (51R) (500R)
(10R) (11R) (200R) (LI)
(SW) (MU) (ID) (ML)
CIRCLE 816

Motorola
Power Products
5005 E. McDowell Rd.
Phoenix, AZ 85008
(602) 244-5757
(BT) (MF) (RE) (TH) (PI) (PC)
CIRCLE 817

Multiplier Industries Corp.
135 Radio Circle
Mt. Kisco, NY 10549
(914) 241-9510
(AL) (CZ) (LC) (LT) (NC) (NM)
CIRCLE 818

NH Research Inc.
16601 Hale Ave.
Irvine, CA 92714
(714) 474-3900
(50S) (51S) (10S) (11S)
(200S) (RM) (CV) (RP) (MD)
CIRCLE 819

Natel Engineering Co. Inc.
Power Microelectronics
845 Rancho Conejo Blvd.
Newbury Park, CA 91320
(805) 376-5500
(BT) (MF) (RE) (TH) (PI) (PC)
CIRCLE 820

National Custom Enterprises
400 Gateway Blvd.
Burnsville, MN 55337-2559
(612) 890-1360
(AL) (CZ) (LC) (LT) (NC)
(NM) (SO) (ZA)
CIRCLE 821

National Semiconductor Corp.
Analog - Power Management
2900 Semiconductor Dr.
MS/16-171
Santa Clara, CA 95052
(408) 721-2511
(50C) (51C) (DC) (IC) (MI)
(51R) (LI) (SW) (ID) (ML)
(BT) (MF) (RE) (PI) (PC)
CIRCLE 822

Nova Electric
Div. of Technology Dynamics
100 Schoool St.
Bergenfield, NJ 07621
(201) 385-0500
(200S) (RM) (PR) (MD) (UN)
(PF) (200C) (AC) (MI)
CIRCLE 823

OECO Corp.
4607 S.E. International Way
Milwaukie, OR 97222
(503) 659-7932
(50S) (51S) (500S) (11S)
(200S) (RM) (OF) (RP) (MD)
(PF) (50C) (51C) (500C) (11C)
(11C) (200C) (DC) (MO) (MI)
CIRCLE 824

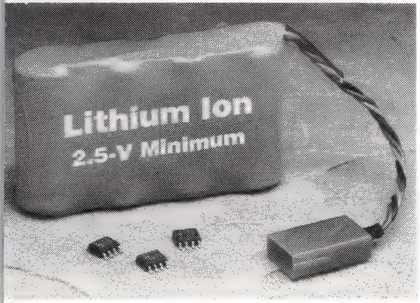
ONEAC Corp.
27944 N. Bradley Rd.
Libertyville, IL 60048
(800) 327-8801
(11S) (200S) (UN)
CIRCLE 825

OPT Industries Inc.
300 Red School Ln.
Phillipsburg, NJ 08865
(908) 454-2600
(50S) (51S) (200S) (RM) (OF)
(CV) (MD) (UN) (PF) (50C)
(51C) (200C) (DC) (MI) (50R)
(51R) (200R) (LI) (SW) (ML)
CIRCLE 826

(see p. 129 for key)

(continued on p. 123)

▼ LOW ON-RESISTANCES MARK SMT MOSFETS



Low-voltage capabilities are combined with extremely low on-resistances in the latest additions to the Little Foot MOSFET family. For example, the p-channel Si9434DY offers an on-resistance of 60 mΩ at a gate voltage of 2.7 V, which is roughly half the level of comparable devices, it's claimed. Aimed at a wide range of portable applications, these low-voltage devices will prolong battery life, reduce component counts, and save board space with their SO-8 packaging. The dual n-channel Si9925DY matches the 2.5-V end-of-charge voltage with an 80-mΩ on-resistance spec at a 2.5-V gate voltage, enabling designers to take full advantage of lithium ion batteries by letting the power supply run down to the end of the battery's voltage range. Used as a reverse blocking switch, the Si9925DY replaces two discretes when its two MOSFETs are connected in series. The complementary n- and p-channel Si9928DY serve as the output stage of a dc-dc converter, offering on-resistance gains over previous-generation devices in the forms of 60 mΩ (n-channel) and 130 mΩ (p-channel). In low-voltage dc-dc converters, the Si9928DY provides higher efficiency and saves board space. In lots of 100,000, prices are $1.14 (Si9925DY), $1.25 (Si9434DY), and $1.19 (Si9928DY). Samples are delivered from stock with large lots taking 8 to 10 weeks.

Siliconix
2201 Laurelwood Rd.
P.O. Box 54951
Santa Clara, CA 95056-0951
(800) 554-5565, ext. 19
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Omega Engineering Inc.
P.O. Box 4047
Stamford, CT 06907
(203) 359-1660
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(RP) (AL) (NC)
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Omnirel Corp.
205 Crawford St.
Leominster, MA 01611
(508) 534-5776
(50C) (11C) (DC) (50R) (LI)
(SW) (ML) (BT) (MF) (RE)
CIRCLE 828

On-Line Power
5701 Smithway
Commerce, CA 90040
(213) 721-5017
(200S) (UN)
CIRCLE 829

Onan Power/Electronics
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Minneapolis, MN 55344-3508
(612) 943-4600
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(200S) (RM) (OF) (CV) (RP)
(UN) (PF) (50C) (51C) (10C)
(11C) (200C) (DC) (AC)
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(714) 898-2691
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(PR) (RP) (UN) (PF)
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Panasonic Industrial Co.
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Panazip: 7C-7
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(BT) (MF) (PI) (PC)
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Battery Sales Group
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(NM) (SO) (ZA) (ZC)
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Power Systems
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B 1301 Wavre, Belgium
+32-10-438502
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(200S) (RM) (OF) (UN)
(PF) (50C) (DC) (MO)
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Phoenix Contact Inc.
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(10C) (11C) (DC) (MO) (50R)
(10R) (11R) (LI) (SW) (MU)
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Power Products
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Mount Vernon, NY 10552
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(11C) (DC) (MO) (MI)
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Pioneer Magnetics Inc.
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(RM) (UN) (PF) (50C) (51C)
(11C) (200C) (DC) (AC) (MO)
(50R) (51R) (11R) (200R) (LI)
(SW) (MU)
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Portable Energy Products
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Scotts Valley, CA 95066
(408) 439-5100
(LC)
CIRCLE 839

Power Conversion Products Inc.
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P.O. Box 380
Crystal Lake, IL 60039-0380
(815) 459-9100
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(PF) (50C) (DC)
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(CV) (PF) (50C) (51C) (500C)
(DC) (AC) (MO) (IC) (50R)
(51R) (500R) (10R) (11R)
(LI) (SW) (MU) (ID)
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(OF) (50C) (10C) (11C)
(DC) (MO) (IC)
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Power Integrations Inc.
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(PI) (PC)
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Power Solutions Inc.
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Roslyn, NY 11576
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(200S) (LA) (RM) (OF) (CV)
(PF) (50C) (51C) (10C) (11C)
(200C) (DC) (MO) (50R) (51R)
(10R) (11R) (200R) (LI) (SW)
(MU) (ID)
CIRCLE 844

Power Switch Corp.
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Lodi, NJ 07644
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(CV) (PF) (50C) (51C)
(11C) (200C) (DC) (AC)
(MO) (50R) (11R) (LI) (SW)
CIRCLE 845

Power Ten Inc.
486 Mercury Dr.
Sunnyvale, CA 94086
(408) 738-5959
(50S) (51S) (500S)
(200S) (LA) (RM) (CV)
(RP) (MD) (SW)
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Batavia, IL 60510
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(50C) (51C) (11C)
(DC) (MO) (50R) (10R)
(11R) (SW) (MU)
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Power-One Inc.
740 Calle Plano
Camarillo, CA 93012
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(11S) (200S) (OF)
(CV) (UN) (PF)
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Power-Sonic Corp.
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Redwood City, CA 94063
(415) 306-1186
(LC) (NC)
CIRCLE 849

PowerTech Inc.
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Fair Lawn, NJ 07410
(201) 791-5050
(BT) (PC)
CIRCLE 850

Powercard Corp.
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Waltham, MA 02154-2014
(617) 890-6789
(AL) (CZ) (LT)
CIRCLE 851

Powercube Corp.
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Billerica, MA 01821
(508) 667-9500
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(MD) (50C) (11C) (200C)
(DC) (MO) (MI)
CIRCLE 852

Powerex Inc.
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(412) 925-7272
(BT) (PI)
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Preferred Electronics Inc.
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Westfield, MA 01086
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(11S) (200S) (RM) (OF) (CV)
(PR) (RP) (MD) (UN) (PF)
(50C) (51C) (500C) (10C)
(11C) (200C) (DC) (AC) (MO)
(MI) (LI) (SW) (MU) (ML)
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(CV) (MD) (50C) (11C)
(200C) (DC) (MO) (MI)
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24003 Ventura Blvd.
Calabasas, CA 91302
(818) 591-8189
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(MD) (PF) (50C) (51C)
(11C) (200C) (DC) (MO) (MI)
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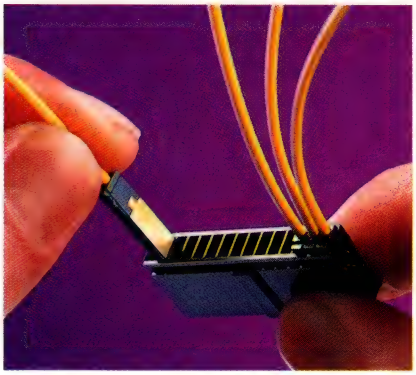
(see p. 129 for key)
(continued on p. 125)

TYPICAL MERITEC CUSTOMER SOLUTIONS

Controlled Impedance Ground Plane Interconnects (GPI™) are Designed to Exceed 1 GHZ System Speeds



Meritec's new Ground Plane Interconnects are engineered to match impedance and propagation rate while minimizing crosstalk. The assemblies are impedance matched from the board through the assembly and designed to reduce signal-to-signal crosstalk. The assemblies are designed for CMOS, ECL or GaAs logic and can handle system speeds exceeding 1 GHZ with 35 picosecond rise times. A passive latch connects the termination to the housing or to a carrier system. Meritec's precision terminations are highly reliable in critical applications. **READER SERVICE 99**

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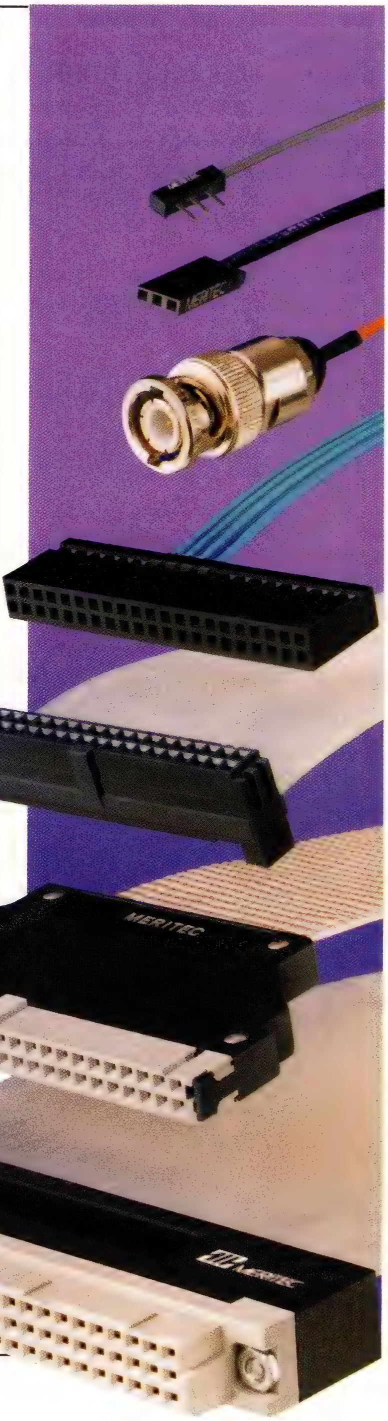
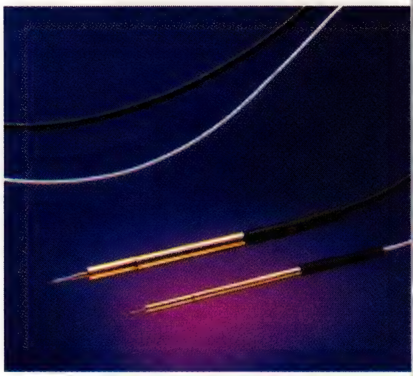


READER SERVICE 98

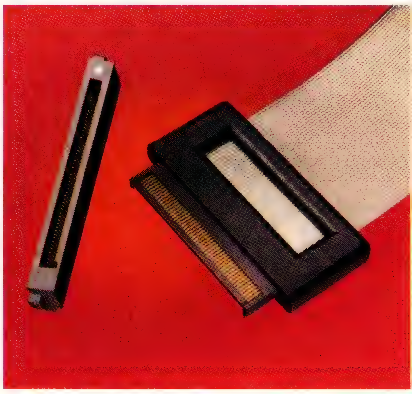
Controlled Impedance Pin Probe Assemblies



Meritec's Pogo Pin Probe Subminiature Cable Assemblies are used in conjunction with automatic test equipment for testing loaded high speed digital circuit cards. The probes are terminated to subminiature shielded coax cable. Pins are connected to the signal conductors of the cables, while the probe barrels are connected to the cable shield. When used with plated through holes or solder contact pads in the PCB, the assemblies provide a continuous shield from the probes to the card under test.

READER SERVICE 100

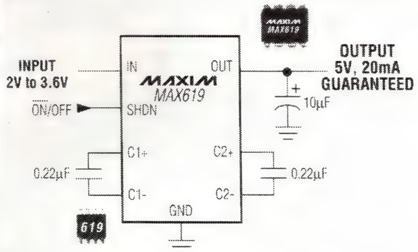
Memory Card Interconnect Systems



Meritec's new 50 position Memory Card Interconnect Systems provide I/O access to Elco PCMCIA card frames. Each system consists of an I/O card connector, which mounts to an Elco card frame, and a mating ribbon cable assembly. The basic design can be expanded to accomodate up to 68 circuits. The cable assembly portion of the system can be manufactured using a variety of cable configurations, including flat ribbon or round/oval. The assemblies are available with or without EMI/RFI electrical shielding. In addition to Elco frames, the system can be made to fit other manufacturers' frame configurations.

READER SERVICE 101

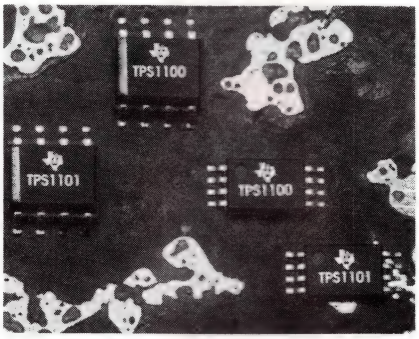
▼ STEP-UP CONVERTER FORGOES INDUCTORS



The output of any two-cell alkaline or nickel cadmium battery, single-cell lithium battery, or 3-V supply system is boosted to 5 V without using inductors by the MAX619 regulated step-up voltage converter. The complete circuit fits into less than 0.1 in.^{2} and uses only two 0.22-μF capacitors and two 10-μF capacitors. It delivers an output voltage of 5 V ±4% at up to 30 mA with 82% efficiency. Its 150-μA quiescent current and 2-to-3.6-V input range make it a useful battery-powered backup supply. Applications include two-cell-battery-to-5-V regulation, local 3-to-5-V conversion, compact 5-V op-amp supplies, and high-side switch drive voltage for MOSFETs in low-voltage systems. Pricing starts at $1.60 in lots of 1000 for 8-pin DIP and SO packages. Small lots are delivered from stock.

Maxim Integrated Products
120 San Gabriel Dr.
Sunnyvale, CA 94086
(408) 737-7600
▶ CIRCLE 929

▼ P-CHANNEL MOSFETS OFFER LOW $R_{DS(ON)}$



The TPS1100/1101 devices are the newest members of a family of p-channel enhancement-mode MOSFETs that offer low $R_{DS(ON)}$ switching without the use of an external driver. Unlike other p-channel MOSFETs, the TPS1100/1101 devices are designed to fit into TSSOP and SOIC packaging. They have a gate-to-source voltage of 1.5 V maximum and a leakage current of only 0.5 μA. Additionally, built-in ESD protection can help increase the reliability of end products. Applications include cellular phones, notebook PCs, PDAs, and PCMCIA cards. Call for pricing and delivery.

Texas Instruments Inc.
Literature Response Center
SC-94022
P.O. Box 172228
Denver, CO 80217
(800) 477-8924, ext. 4500
▶ CIRCLE 930

▼ AC-POWER SOURCE HANDLES EXPORT TEST

The output characteristics of most of the world's utility line-power systems can be replicated by the model 1251WP precision ac-power source. Its low-distortion output can be selected from 100, 115, 220, 230, or 240 V at a continuous rating of 1300 VA. Frequency can be selected to be either 50 or 60 Hz. The system will reliably start loads that require up to 100 A of peak in-rush current. At just 29 lbs, the unit is readily portable. Pricing starts at $2850. Call for delivery information.

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& Electronics
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(CV) (MD)
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Rayovac Corp.
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Lakehills, TX 78063
(210) 751-3220
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(CV) (MD) (PF) (50C) (51C)
(500C) (10C) (11C) (200C)
(DC) (AC) (MI) (50R) (51R)
(500R) (10R) (11R) (200R)
(LI) (SW) (ML)
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Power Products Div.
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Houston, TX 77218
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(50C) (DC) (SW)
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990 N. Bowser Rd., Suite 900
Richardson, TX 75081
(214) 234-8091
(AL) (LT) (ME) (SO) (ZA)
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Resonant Power
Technology Inc.
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San Jose, CA 95131-2102
(408) 441-0800
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(OF) (MD) (PF)
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Hingham, MA 02043
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(11S) (200S) (RM) (PF) (50C)
(51C) (500C) (10C) (11C)
(200C) (DC) (AL) (LT)
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Samsung Semiconductor
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(AL) (LT) (NC) (NM)
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Schaefer Inc.
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Ashland, MA 01721
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(RM) (50C) (51C) (11C)
(200C) (DC) (AC) (SW)
CIRCLE 868

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Sub. of Astec America Inc.
49 Range Rd.
Windham, NH 03087
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(RM) (CV) (50C) (51C) (10C)
(11C) (DC) (MO) (IC)
CIRCLE 869

Semtech Corp.
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(805) 498-2111
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(DC) (AC) (MO) (IC) (50R)
(10R) (11R) (LI) (SW) (MU)
(ID) (ML) (BT) (RE) (PI) (PC)
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(10C) (11C) (200C) (DC) (AC)
(MO) (50R) (10R) (11R) (SW)
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Great Neck, NY 11021-4799
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(50C) (51C) (10C) (11C)
(200C) (DC) (AC) (MO) (50R)
(LI) (MU) (AL) (CZ) (LT) (ME)
(NC) (NM) (SO) (RE)
CIRCLE 872

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Siemens Components Inc.
10950 N. Tantau Ave.
Cupertino, CA 95014
(408) 777-4542
(MF) (PI)
CIRCLE 873

Sierra West Power Systems
300 N. Telshor Blvd.
Suite 500
Las Cruces, NM 88001
(505) 522-8828
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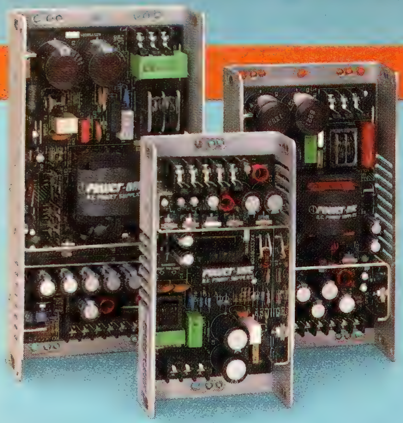
(11S) (200S) (RM) (OF)
(CV) (RP) (MD) (UN) (PF)
(50C) (51C) (500C) (10C)
(11C) (200C) (DC) (AC) (MO)
(IC) (MI) (50R) (51R) (500R)
(10R) (11R) (200R) (LI) (SW)
(MU) (ID) (ML)
CIRCLE 874

(see p. 129 for key)

(continued on p. 127)

POWER-ONE D.C. POWER SUPPLIES

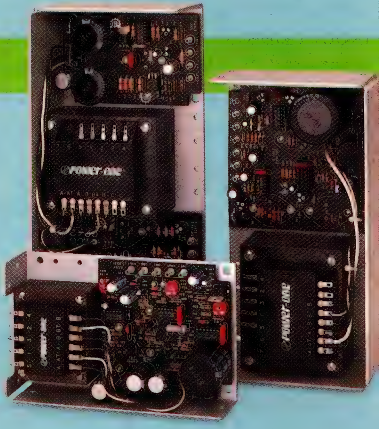
Not Only The Best...The Best Selection, Too



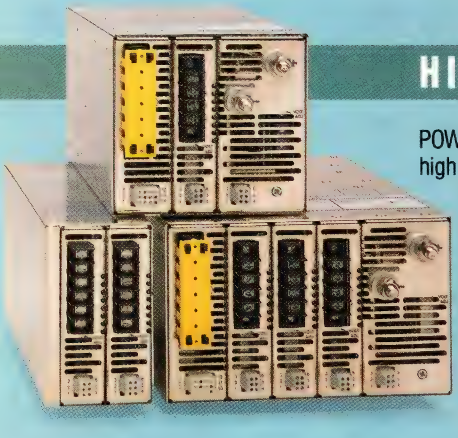
SWITCHERS

POWER-ONE'S International Switcher Series incorporates the latest state-of-the-art switching technology while providing POWER-ONE's traditional high quality at low prices. With certification to the world's toughest safety agency requirements, the series is especially suited for products sold not only domestically, but internationally as well. **• 85 models. . .40 watts to 400 watts • Efficient. . .reliable. . .economical • VDE construction • Up to 5 fully regulated outputs • Full international safety and EMI approvals**

LINEARS



POWER-ONE'S International Linear Series is the world's undisputed leader in versatile, cost-effective linear power supply products. A long-time favorite of designers and engineers worldwide, the series is the most widely purchased power supply line through distribution in the industry. The most popular voltage and current combinations are available in a wide variety of off-the-shelf standard models. **• Popular industry standard packages • 77 models. . . 6 watts to 280 watts • ± 0.05% regulation • Up to 4 fully regulated outputs • Worldwide safety approvals**



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POWER-ONE'S International High Power Series is a true fully-modular high power product line. Specify a power system that meets your exact requirements from a wide selection of single, dual and triple output plug-in power modules. Virtually any combination of output voltage and current rating can be delivered from stock. **• 500 watts to 2,000 watts • Fully modular construction • Up to 15 fully regulated outputs • UPS battery backup option • Parallelable outputs with current sharing • Power Factor Correction optional**

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740 Calle Plano · Camarillo, CA 93012-8583
Phone: (805) 987-8741 · FAX: (805) 388-0476

READER SERVICE 114

POWER-SOURCE MANUFACTURERS

Silicon Transistor Corp.
27 Katrina Rd.
Chelmsford, MA 01824
(508) 256-3321
(BT) (MF) (RE) (TH)
CIRCLE 875

Siliconix Inc.
2201 Laurelwood Rd.
Santa Clara, CA 95056
(800) 554-5565
(MF) (PI)
CIRCLE 876

Sola
1717 Busse Rd.
Elk Grove Village, IL 60007
(708) 439-2800
(50S) (10S) (11S) (RM)
(OF) (CV) (PF)
CIRCLE 877

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615 N. Railroad Ave.
Paxton, IL 60957
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(11S) (200S) (LA) (RM)
(CV) (RP) (PF) (50C) (200C)
(DC) (MO)
CIRCLE 878

Speco/Emco Electronics
1172 Rt. 109
Lindenhurst, NY 11757
(516) 957-8700
(50S) (LA) (50C) (AC)
CIRCLE 879

Spellman High Voltage
Electronics
7 Fairchild Ave.
Plainview, NY 11803
(516) 349-8686
(500S) (200S) (LA) (RM)
(OF) (CV) (RP) (PF) (DC)
(MO) (LI) (SW)
CIRCLE 880

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(408) 744-9040
(500S) (11S) (LA)
(RM) (CV) (RP)
CIRCLE 881

Supertex Inc.
1350 Bordeaux Dr.
Sunnyvale, CA 94089
(408) 744-0100
(MF) (PI) (PC)
CIRCLE 882

Switching Power Inc.
3601 Veterans Hwy.
Ronkonkoma, NY 11779
(516) 981-7231
(50S) (200S) (OF) (CV) (PF)
(50C) (200C) (DC) (50R)
(11R) (200R) (SW)
CIRCLE 883

Switching Systems Int'l.
500 Porter Way
Placentia, CA 92670
(714) 996-0909
(50S) (11S) (200S) (OF)
(PF) (50C) (11C) (200C)
(DC) (50R) (SW)
CIRCLE 884

Taltronics Corp.
Div. of Dimetrics Inc.
404 Armour St., P.O. Box 339
Davidson, NC 28036
(704) 896-8185
(50S) (51S) (10S) (11S)
(200S) (RM) (OF) (CV) (PF)
(50C) (51C) (11C) (200C)
(DC) (LI) (SW)
CIRCLE 885

Tamura Corp. of America
P.O. Box 892230
Temecula, CA 92589-2230
(909) 699-1270
(50S) (10S) (11S) (200S) (OF)
(RP) (UN) (PF) (50C) (51C)
(10C) (DC) (AC) (IC) (50R)
(11R) (200R) (LI) (SW) (MU)
CIRCLE 886

Tauber Electronics Inc.
4901 Morena Blvd., Suite 314
San Diego, CA 92117
(619) 274-7242
(UN) (AL) (CZ) (LC) (LT)
(ME) (NC) (NH) (NM) (SO)
(ZA) (ZC)
CIRCLE 887

Technology Dynamics Inc.
100 School St.
Bergenfield, NJ 07621
(201) 385-0500
(50S) (51S) (500S) (10S)
(11S) (200S) (LA) (RM) (OF)
(CV) (RP) (MD) (UN) (PF)
(50C) (51C) (10C) (11C)
(200C) (DC) (MI)
CIRCLE 888

Tecnetics
6287 Arapahoe Ave.
Boulder, CO 80303
(303) 442-3837
(50S) (51S) (500S) (10S)
(11S) (200S) (RM) (CV) (RP)
(MD) (UN) (PF) (50C) (51C)
(500C) (10C) (11C) (200C)
(DC) (MO) (MI) (50R) (51R)
(500R) (10R) (11R) (200R)
(LI) (SW) (ML)
CIRCLE 889

Telcom Semiconductor
1300 Terra Bella Ave.
Mountain View, CA 94039
(415) 968-9241
(DC) (PI) (PC)
CIRCLE 890

Texas Instruments Inc.
Literature Response Center
P.O. Box 172228
Denver, CO 80217
(800) 477-8924, ext. 4500
(50C) (DC) (50R) (LI)
(SW) (BT) (MF) (PI)
CIRCLE 891

The Vector Group Inc.
189 Horsham Rd.
Horsham, PA 19044
(215) 672-6702
(50S) (LA) (RM) (CV)
CIRCLE 892

Todd Products Corp.
50 Emjay Blvd.
Brentwood, NY 11717-4905
(516) 231-3366
(50S) (51S) (11S) (200S) (OF)
(CV) (RP) (UN) (PF) (50C)
(51C) (11C) (200C) (DC) (MO)
CIRCLE 893

Toko America Inc.
1250 Feehanville Dr.
Mount Prospect, IL 60056
(708) 297-0070
(50S) (10S) (11S) (200S)
(OF) (CV) (PF) (50C) (10C)
(DC) (AC) (50R) (10R) (LI)
(SW) (PC)
CIRCLE 894

Toshiba America
Electronic Components Div.
9775 Toledo Way
Irvine, CA 92718
(800) 879-4963
(500C) (LT) (BT) (MF)
(RE) (PI)
CIRCLE 895

Total Power International
Inc.
418 Bridge St.
Lowell, MA 01850
(508) 453-7272
(50S) (10S) (11S) (200S) (OF)
(50C) (10C) (11C) (200C)
(DC) (MO) (IC) (50R) (10R)
(11R) (LI) (SW) (MU)
CIRCLE 896

Transistor Devices Inc.
85 Horsehill Rd.
Cedar Knolls, NJ 07927
(201) 267-1900
(50S) (51S) (500S) (11S)
(200S) (LA) (RM) (CV) (PR)
(RP) (MD) (UN) (PF) (50C)
(51C) (500C) (11C) (200C)
(DC) (AC) (MO) (MI) (50R)
(51R) (500R) (11R) (200R)
(LI) (SW) (MU) (ML)
CIRCLE 897

Tri Source Inc.
415 Howe Ave.
Shelton, CT 06484
(203) 924-7030
(50S) (51S) (500S) (10S)
(11S) (200S) (RM) (OF)
(CV) (MD) (UN) (PF) (50C)
(10C) (11C) (200C) (DC) (MO)
(MI) (50R) (51R) (500R)
(10R) (11R) (200R) (LI)
(SW) (MU) (ML)
CIRCLE 898

Tri-Mag Inc.
1601 N. Clancy Ct.
Visalia, CA 93291
(209) 651-2222
(50S) (51S) (10S) (11S)
(200S) (OF) (UN) (PF)
(50C) (51C) (10C) (11C)
(DC) (AC) (MO) (IC) (50R)
(51R) (SW) (MU)
CIRCLE 899

Tripp Lite
500 N. Orleans
Chicago, IL 60610-4188
(312) 329-1601
(50S) (51S) (200S) (RM)
(CV) (PR) (UN) (PF) (51C)
(AC) (51R) (200R) (SW)
CIRCLE 900

(see p. 129 for key)

(continued on p. 129)

▼ 6-A MOSFET DRIVER UPS SWITCHING RATES

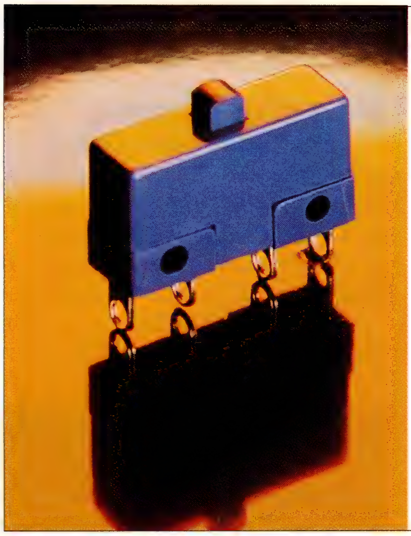
An alternative to complex discrete solutions for achieving sufficient switching frequencies to reduce the size and weight of power supplies is available for military applications. The HV400MJ/883 pulse transformer/MOSFET interface IC is processed to MIL-STD-883 specs. It's a 6-A (peak) monolithic MOSFER driver for use as a power-switch building block for high- and low-side switches, secondary-side regulators, and synchronous rectifiers. The IC drives a power MOSFET from a pulse transformer at switching rates up to 300 kHz. Unless such designs use either this IC or a complex assembly of discretes, the pulse transformer limits the switching frequency to less than 100 kHz. In 8-pin, side-brazed CERDIPs, the HV400MJ/883 is available for $12.83 in lots of 1000.

Harris Semiconductor
P.O. Box 883
Melbourne, FL 32901
(800) 4-HARRIS
▶CIRCLE 932

▼ 1000-W CONVERTERS MEET MIL STANDARDS

A series of high-density, single-output ac-dc/dc-dc converters is now available as non-developmental items and for custom modification. The HPM Series accepts either 115 V ac single-phase, 115-/200-V ac three-phase, 28 V dc, or 270 V dc inputs and provides up to 1000 W (2000 W pulse) at from 2 to 300 V dc (200 A maximum). Features include active current-sharing circuitry for N+1 parallel operation, output overcurrent and overvoltage protection, full I/O isolation, synchronization, and excellent dynamic-load response. Price varies with configuration and customization. Call for delivery.

Lambda Novatronics Inc.
500 S.W. 12th Ave.
P.O. Box 878
Pompano Beach, FL 33061-0878
(305) 942-5200
▶CIRCLE 933

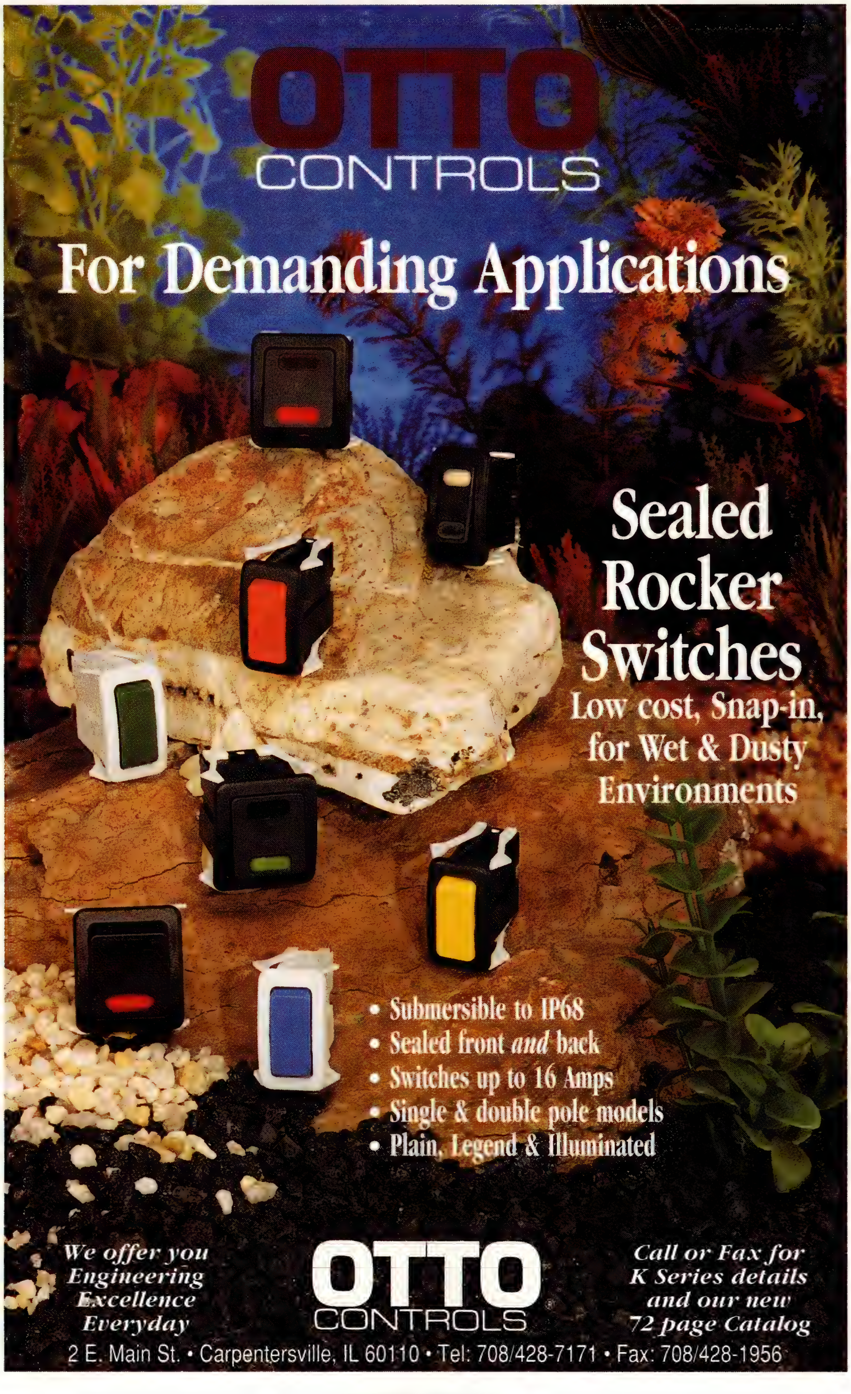


DOUBLE-BREAK SUBMINIATURE BASICS

May be subminiature in size but these basics switch up to 10 amperes with 100,000 minimum cycle life; over 1 million cycle mechanical life! Constructed in accordance with MIL-S-8805/7. UL recognized. Precision operating points.

Replaces ITW Switches Type 16. Ask for B5 series.

READER SERVICE 110



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Sealed Rocker Switches

Low cost, Snap-in, for Wet & Dusty Environments

- Submersible to IP68
- Sealed front *and* back
- Switches up to 16 Amps
- Single & double pole models
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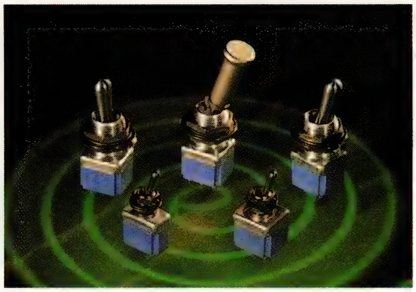
READER SERVICE 195

ENVIRONMENT-FREE SEALED SWITCHES

Withstands immersion and corrosive atmospheres. Designed for rugged duty both mechanically and electrically. One-piece stainless steel housings sealed at the plunger with ring seals and at the base with glass-to-metal header. **Replaces C-H/Eaton H11, Microswitch EN and ITW Type 63.** Ask for P6 series.

READER SERVICE 111

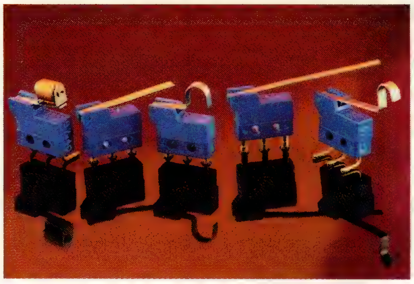


SEALED MINI TOGGLES

Rugged and highly reliable, these toggles weigh 25% less than others. Positive detent. Non-teasible contact transfer. One or two poles, momentary, maintained and lever-lock-out operation. Rated 5 A. Qualified to MIL-S-83731.

Replaces C-H/Eaton 88, Microswitch TW. Ask for T3 series.

READER SERVICE 112

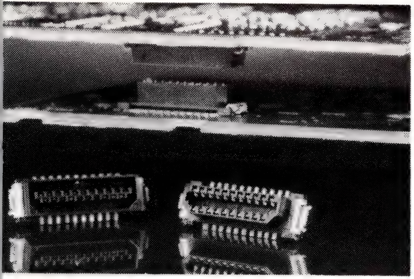


SINGLE-BREAK BASICS

Commercial and Military grades, available in two widths. Switch up to 7 amperes. Available with integral levers as B2-5 series. UL recognized and CSA certified. **Replaces C-H/Eaton SS10 & SS30, Microswitch SX, Unimax MM5 & MM6.** Ask for B2 series.

READER SERVICE 196

▼ TINY SMT CONNECTOR KEEPS SIGNALS PURE



The integrity of signal transmissions n high-density packaging is maintained by the Millipede, a tiny surface-mounted connector. Standing ust 0.156 in. tall, the device is a two-piece affair for use in portable phones, pagers, camcorders, PDAs, notebook PCs, and commercial radios. Typically, the Millipede connector offers a current-carrying capacity of 0.5 A per contact, a 50-mΩ termination resistance, and an operating-temperature range of –40 to 85°C. Contacts are on a 1-mm pitch for extremely high interconnection density. Call for pricing and delivery.

Augat Inc.
452 John Dietsch Blvd.
Attleboro Falls, MA 02763
(508) 699-7646
▶ **CIRCLE 934**

▼ SMT SOCKETS, HEADERS SUIT BOARD STACKING

A micro-miniature socket on 0.050-by-0.100 centers and matching headers are available for board-stacking applications. The RSM Series sockets feature a 0.235-in. profile and come in single- and double-row designs. The HTMS Series headers are offered in through-hole and SMT versions for mated heights down to 0.385 in. An edge-mount option is also available. Board-stacking headers (HDWM Series) achieve mated heights from 0.465 to 0.780 with the RSM sockets. Cost is from $0.06 per pin for the RSM Series and from $0.035 and $0.04 per pin, respectively, for the HTMS and HDWM Series. Delivery is in five days from receipt of order.

Samtec Inc.
P.O. Box 1147
New Albany, IN 47151-1147
(800) SAMTEC-9
▶ **CIRCLE 935**

▼ PCMCIA CONNECTORS LEND STABILITY

An extensive line of components for Types I, II, and III PCMCIA memory cards provides key design advantages including mechanical stability, ease of assembly, and broad layout flexibility. The components meet PCMCIA Release 2.01 and JEIDA Version 4.1 standards. The 5098 Series features a 68-position receptacle connector and a wide array of associated hardware including frames, covers, and I/O connectors. A reliable, dual-beam contact system is tested to 50,000 cycles. Call for pricing and delivery.

Elco Corp.
A Kyocera Group Co.
Huntingdon Industrial Park
Huntingdon, PA 16652
(814) 643-0700
▶ **CIRCLE 936**

POWER-SOURCE MANUFACTURERS

Ultralife Batteries Inc.
1350 Route 88 South
Newark, NY 14513
(315) 332-7100
(LT)
CIRCLE 901

Unipower Corp.
3900 Coral Ridge Dr.
Coral Springs, FL 33065
(305) 346-2442
(50S) (200S) (RM) (OF)
(PF) (50C) (200C) (DC)
CIRCLE 902

Unitrode Integrated Circuits
7 Continental Blvd.
Merrimack, NH 03054
(603) 424-2410
(50R) (51R) (10R) (LI) (SW)
(ID) (ML) (MF) (PI) (PC)
CIRCLE 903

Upsonic
29 Journey
Aliso Viejo, CA 92656
(714) 448-9500
(50S) (51S) (500S) (UN)
CIRCLE 904

Valor Electronics Inc.
9715 Business Park Ave.
San Diego, CA 92131-1642
(619) 537-2500
(50C) (10C) (DC)
CIRCLE 905

Varta Batteries Inc.
300 Executive Blvd.
Elmsford, NY 10523-1202
(914) 592-2500
(AL) (LC) (LT) (ME)
(NC) (NM) (SO) (ZA)
CIRCLE 906

Vicor Corp.
23 Frontage Rd.
Andover, MA 01810
(508) 470-2900
(50S) (51S) (CV) (MD) (PF)
(50C) (51C) (DC) (MO) (MI)
CIRCLE 907

Viking Industrial Products
729 Farm Rd.
Marlboro, MA 01752
(508) 481-4600
(50S) (51S) (10S) (11S)
(200S) (OF) (CV) (PR)
(50C) (51C) (10C) (11C)
(200C) (DC) (AC) (50R) (51R)
(11R) (200R) (LI) (SW)
CIRCLE 908

Voltex Co. Inc.
3460 Great Neck Rd.
Amityville, NY 11701
(516) 842-2772
(50S) (51S) (10S) (11S)
(200S) (OF) (CV) (RP) (PF)
(50C) (51C) (10C) (11C)
(200C) (DC) (LI) (SW)
CIRCLE 909

Wall Industries Inc.
5 Watson Brook Rd.
Exeter, NH 03842
(603) 778-2300
(50S) (10S) (11S) (200S)
(OF) (CV) (50C) (51C)
(500C) (10C) (11C) (200C)
(DC) (MO) (IC)
CIRCLE 910

Wayne Kerr/Farnell
11 Sixth Rd.
Woburn, MA 01801-1744
(617) 938-8390
(50S) (51S) (10S) (11S)
(200S) (LA) (RM) (CV) (RP)
CIRCLE 911

Wilson Greatbatch Ltd.
Electrochem Battery Div.
10000 Wehrle Dr.
Clarence, NY 14031
716) 759-6901
(LT)
CIRCLE 912

Xentek Inc.
1770 La Costa Meadows Dr.
San Marcos, CA 92069
(619) 471-4001
(50S) (11S) (200S) (RM)
(OF) (CV) (MD) (PF) (50C)
(10C) (11C) (200C) (DC) (IC)
(MI) (50R) (10R) (11R) (200R)
(LI) (SW) (ID) (ML)
CIRCLE 913

Yuasa-Exide Inc.
Stationary Battery Div.
P.O. Box 14145
Reading, PA 19612-4145
(215) 378-0333
(LC) (NM)
CIRCLE 914

Zenith Electronics Corp.
Power Supplies Div.
1000 Milwaukee Ave.
Glenview, IL 60025-2493
(708) 391-8510
(11S) (200S) (OF) (PF)
CIRCLE 915

KEY

Power Supplies

Output

(50S)	To 50 V
(51S)	51 to 500 V
(500S)	Over 500 V
(10S)	To 10 W
(11S)	11 to 200 W
(200S)	Over 200 W

Types

(LA)	Laboratory
(RM)	Rack mounting
(OF)	Open-frame OEM
(CV)	Constant voltage/current
(PR)	Precision ac output
(RP)	Remote programming
(MD)	Military designs
(UN)	Uninterruptible
(PF)	Power-factor-corrected

Power Converters

Output

(50C)	To 50 V
(51C)	51 to 500 V
(500C)	Over 500 V
(10C)	To 10 W
(11C)	11 to 200 W
(200C)	Over 200 W

Types

(DC)	Dc to dc
(AC)	Dc to ac
(AT)	Ac to dc
(MO)	Modular
(IC)	IC DIP
(MI)	Military designs

Power Regulators

Output

(50R)	To 50 V
(51R)	51 to 500 V
(500R)	Over 500 V
(10R)	To 10 W
(11R)	11 to 200 W
(200R)	Over 200 W

Types

(LI)	Linear
(SW)	Switching
(MU)	Modular
(ID)	IC DIP
(ML)	Military designs

Batteries

Output

(AL)	Alkaline
(CZ)	Carbon zinc
(LC)	Lead acid
(LT)	Lithium
(ME)	Mercury
(NC)	Nickel cadmium
(NH)	Nickel hydrogen
(NM)	Nickel metal hydride
(SO)	Silver oxide
(ZA)	Zinc air
(ZC)	Zinc chloride

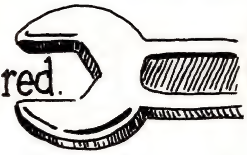
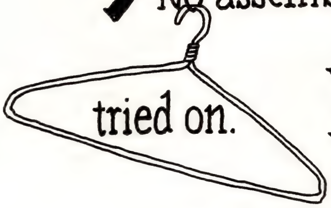
Power Semiconductors

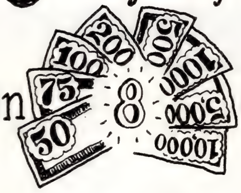
Output

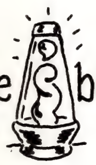
(BT)	Bipolar transistors
(MF)	MOSFETs
(RE)	Rectifiers
(TH)	Thyristors
(PI)	Power ICs
(PC)	Power-control ICs

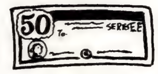
The top 10 reasons to give U.S. Savings Bonds:

10 They don't require batteries.

9 No assembly required.  8 They don't need to be  tried on. 7 You can send them anywhere without having to pack them in big, brown boxes filled with .

6 They only come in one color. 5 They're available in  denominations.

4 Even if they already have one, they'll certainly appreciate another. 3 They make you look like a bigger spender than you really are. 2 They won't be out of style  before they arrive. 1 People ALWAYS remember the people who give them Savings Bonds.

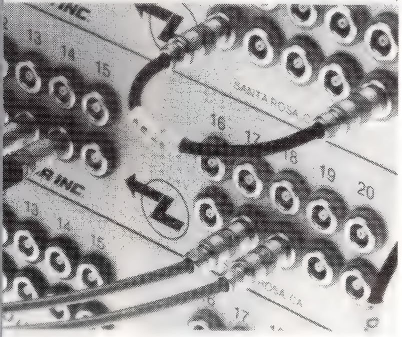
Go to your , buy a , ask for a gift certificate – and be remembered.

Take Stock in America U.S. SAVINGS BONDS

A public service of this magazine

COAXIAL CONNECTORS HANDLE HIGH FREQUENCIES

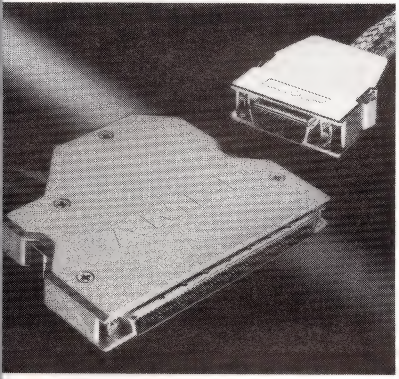
50-Ω coaxial connector with prov-
n performance at frequencies to 12
Hz is specifically designed for RF
pplications requiring self latching
nd quick connect/disconnect. The R
eries connectors come in various



hell styles and feature precision ma-
hined parts including chrome-plat-
l brass shells and gold-plated con-
icts. Specifications include a VSWR
f less than 1.25:1 and insertion-loss
erformance of 0.25 dB maximum
er connector at 12 GHz. The connec-
ors' compact size and latching sys-
em make them suitable for applica-
ons requiring high connector densi-
in limited space. Units measure
bout 1 in. in length and can accom-
odate various coaxial cables. En-
agement and disengagement is
uick and easy. Pricing starts at
8.92 per mated pair in lots of 100.
elivery is from stock to 12 weeks.

LEMO USA Inc.
P.O. Box 11488
Santa Rosa, CA 95406
(800) 444-5366
▶CIRCLE 560

CABLE ASSEMBLIES MEET HIGH-DENSITY NEEDS

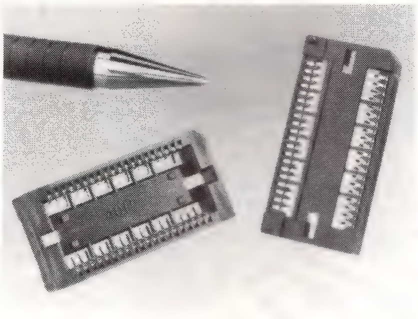


wo configurations of the AMPLI-
ITE 0.050 Series cable assemblies
rovide fully shielded, high-density
terconnections for either SCSI-2, IPI-2, or HIPPI-standard cabling needs; or for coax and shielded differential-pair cabling needs. The connectors, which are on 0.050-by-0.100-in. centers, provide high shielding effectiveness as well as ESD protection. For coax and shielded differential-pair cable uses, the connectors are resistance-welded to controlled-Z cables. Applications include computer systems, automatic test systems, and telecommunication-switching equipment. Call for pricing and delivery information.

AMP Inc.
P.O. Box 3608
Harrisburg, PA 17105-3608
(800) 522-6752
▶CIRCLE 561

▼ SURFACE-MOUNT SOCKETS ACCEPT SOJ DEVICES

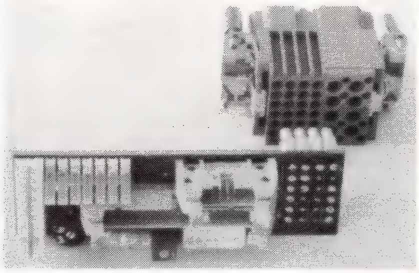
A line of SMT sockets for pin-to-pin socketing of small-outline J-lead (SOJ) devices is available in a variety of sizes. The Series 536 sockets come in 24-, 26-, 28-, and 32-pin versions with short leads and in 28- and 40-pin versions with long leads. Pin-to-pin spacing is 0.050 in. The sockets are rated at 1 A maximum with a temperature rating from –55 to 105°C and an initial insulation resistance of 10,000 MΩ minimum. Typical pricing for a 32-pin Series 536 SOJ socket is $0.74 in lots of 5000. Delivery is from stock to 6 weeks.



Aries Electronics Inc.
P.O. Box 130
Frenchtown, NJ 08825
(908) 996-6841
▶CIRCLE 562

▼ PC-BOARD ADAPTER MOVES SIGNALS OUT

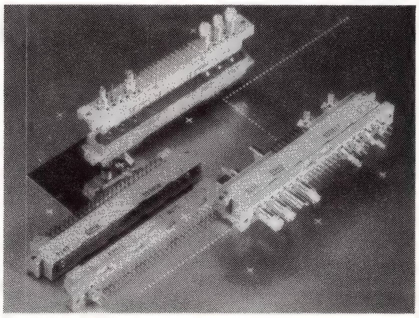
Pc-board users can take advantage of the Han pc-board adapter in any situation where signals or power must travel from a board inside an enclosure to the outside world. The sturdy connector withstands rugged environments ranging from automotive plants to steel mills to offshore drilling rigs. The adapter and its special contacts allow the Han DD (high-density, heavy-duty industrial) inserts to terminate directly onto a pc board. When assembled, users can quickly connect or disconnect one cable containing up to 216 contacts at 7.5 A each. Call for pricing and delivery.



Harting Elektronik Inc.
2155 Stonington Ave., Suite 212
Hoffman Estates, IL 60195-0710
(708) 519-7700
▶CIRCLE 563

▼ DIN 41612 CONNECTORS SUIT TELECOM TASKS

A full line of hybrid connectors for signal, power, and RF interfaces has been modified to include high-current contacts for press-fit termination. The Type M DIN 41612 connectors offers a complete range of male and female connectors with 2-, 4-, 6-, 8-, or 10-contact configurations. Power loads as high as 40 A per contact are attainable. The connectors are engineered especially for applications in telecommunications and data processing in which packaging density requires mixing of regular signal connections with either power and/or RF signals. Call for pricing and delivery.



ERNI Components Inc.
520 Southlake Blvd.
Richmond, VA 23236
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▶CIRCLE 564

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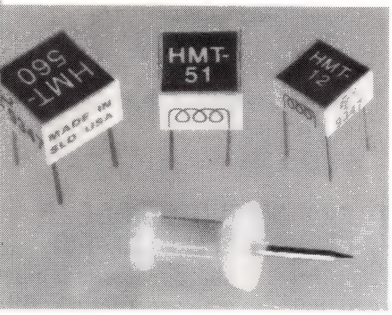
TOROIDAL INDUCTORS MOUNT HORIZONTALLY

-board real estate is conserved by miniature, low-silhouette toroidal ductor that mounts horizontally. ne HMT inductors come in 121 val- s from 0.10 μH to 10,000 μH. ney're designed to obtain minimum stributed capacity, maximum Q,

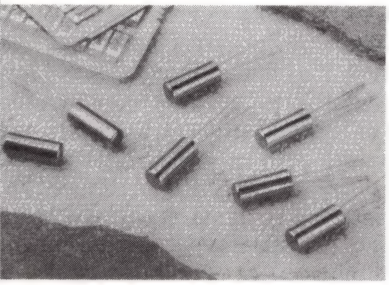


d the highest self-resonant fre- ency. Featuring through-hole ads, the inductors' specifications e identical to the company's exist- g SMT horizontal inductors. The rough-hole configuration helps re- ze maximum inductance per unit lume. Devices are epoxy-encapsu- ted in plastic shells. Prices start at in small lots and are less than $4 in s of 100. Delivery is in 4 weeks.

Engineered Components Co.
3580 Sacramento Dr.
P.O. Box 8121
San Luis Obispo, CA 93403-8121
(805) 544-3800
▶ **CIRCLE 565**

200-MHZ FUNDAMENTALS BUOY MINI CRYSTALS

anks to a manufacturing break- rough, SaRonix now offers minia- re quartz-crystal components with ndamental frequencies to 200



Hz. Using its Tab-mesa technology mT), simple and reliable crystals th third-overtone frequencies to 0 MHz can be used in applications nere less stable ceramic resonators complex surface-acoustic-wave equency references had been the ly options. Both 2-by-6-mm tubular and HC45/UM1 metal packages are available now with ceramic packages planned. When mounted in conventional uncompensated, compensated, or voltage-controlled oscillator packages, the TmT crystals are hermetically double-sealed. This eliminates the most common sources of crystal failures in hybrid oscillators: breakage and contamination. Call for pricing and delivery.

SaRonix
151 Laura Lane
Palo Alto, CA 94303
(415) 856-6900
▶ **CIRCLE 566**

▼ METALIZED FILM CAPS ACCEPT 110-A PEAKS

Continuous currents to 30 A and peak currents to 110 A are no problem for the Type 935 metalized polypropylene-film capacitors for ac and pulse operation. The devices are well-suited for 20-to-100-kHz switching power-input filtering, dc blocking, and output-filter applications where high current, high capacitance, and low ESR values are important. Capacitance values range from 1 to 30 μF and voltages run from 100 to 400 V dc (70 to 275 V ac) with an operating-temperature range of –55 to 105°C. Pricing starts at $1.12 in lots of 500. Delivery is from stock to 12 weeks.

Cornell Dubilier
1605 E. Rodney French Blvd.
New Bedford, MA 02744
(508) 996-8561
▶ **CIRCLE 567**

▼ COMPACT ELECTROLYTICS OFFER HIGH VALUES

A series of snap-in, subminiature aluminum electrolytic capacitors offers values from 47 to 33,000 μF at a tolerance of ±20% over a voltage range of 16 to 450 V dc. The SI Series measures as small as 22 mm deep by 20 mm long and is well suited for use in medical electronics, automobiles, PCs, and disk drives. Operating temperatures are from –40 to 85°C, and load life is rated at 2000 hours ±12 hours at the maximum rated voltage. Delivery is from stock.

NTE Electronics Inc.
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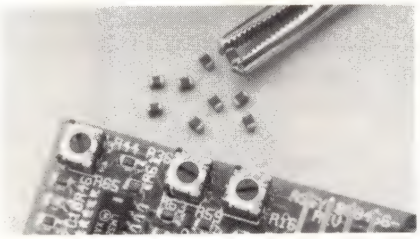
▼ SHIELDED CHIP INDUCTOR COMES IN 0805 PACKAGE

A chip inductor that features zero percent coupling and high heat resistance is avaiable in an 0805-package size. The MIC-0805 multilayer chip inductors are available in 28 individual part numbers, all of which provide 100% shielding. This shielding prevents electromagnetic radiation from interfering with the performance of adjacent components and,
in turn, makes possible higher con
ponent density. Values range fro
0.047 to 10 μH with correspondin
minimum Q values from 15 to 5
Standard tolerances are 10% fo
most parts with tighter tolerance
available. Maximum dc resistance
range from 0.20 to 1.15 Ω. Pricing
$0.20 in lots of 100,000.



Associated Components Technology
11576 Trask Ave.
Garden Grove, CA 92643
(714) 636-2645
▶ CIRCLE 569

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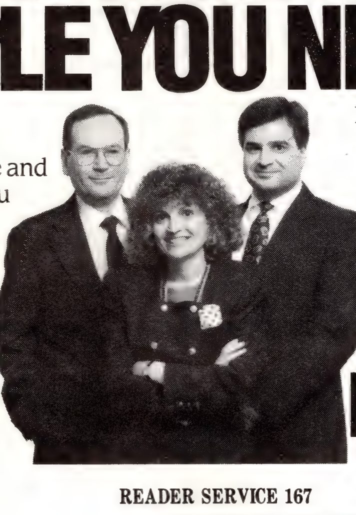

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aged with a color-correcting filt
that responds comparably to the h
man eye. The detectors are based o
Centronic's blue-enhanced Series 5
detectors with the addition of th
correcting filter. A wide variety o
sizes and package configuratio
are available. The units can be use
for monitoring and measuring vis
ble ambient light in applicatio
from light meters to instrument-pa
el controls. Call for pricing and deli
ery.

Centronic Inc.
2088 Anchor Ct.
Anchor Business Park
Newbury Park, CA 91320
(805) 499-5902
▶ CIRCLE 570

▼ AlInGaP AMBER LED SHINES IN SUNLIGHT

Available in a variety of lamp bas
and panel-mount and pc-board co
figurations, the model 200-A3K LE
is an AlInGaP device that features
luminous intensity rating of 30
mcd. This makes it suitable for hig
brightness indication and outdo
sunlight applications. At a pea
wavelength of 594 nm, the high-i
tensity amber LED is offered in
water-tight panel-mount configur
tion (PMR200-A3K, shown) with
voltage range of 5 V dc to 220 V a
Pricing for the PMR200-A3K (5 to
V) is $2.66 in lots of 1000. Delivery
in 4 to 6 weeks.

Data Display Products
445 S. Douglas St.
El Segundo, CA 90245-4630
(310) 640-0442
▶ CIRCLE 571

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Our new HD-PAK™ Series DC/DC Converters give you the most output power, the highest performance and the best features. It's that simple. You won't find a true 54 watts/in^3 density - 300W output - anywhere else in an industry standard package. The 48VDC Input HD-PAK Series is designed specifically for telecommunications applications and offers efficiencies up to 90%.

Our high power density HD-PAK Standard Model provides 40 Amps of output at 5VDC, and the Turbo Model delivers 60 Amps of output at 5VDC, both with up to 85°C base plate temperature.

Call, fax or write us today for more information.

HD-PAK Features

- Fixed 350Khz operation
- -40°C To +100°C (75% full load at 100°C)
- Low output ripple
- Parallel capability
- Outputs 2.6, 3.3, 5, 12, 15, 24, 28 & 48VDC
- Synchronization - from internal or external source
- Up to 90% efficiency
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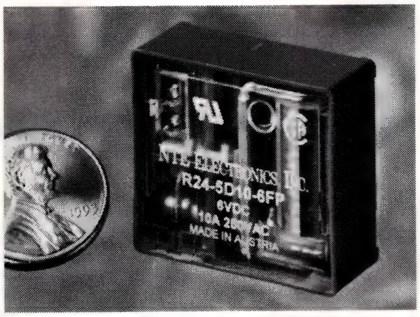
SWITCHES & RELAYS

▼ DC-RELAY LINE COMES IN FLAT PACK

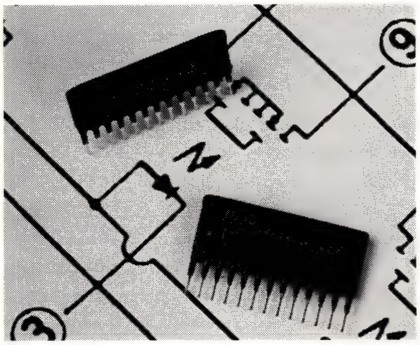
A flat-pack version of the R24 Series of dc relays is now available. The flat-pack relays can now be placed on pc boards with height constraints, such as those that are rack-mounted. Units are epoxy sealed for wave soldering and cleaning. In addition, they have a cut-off nib after pcb washing to extend contact life and lower operating temperature. Contacts are SPDT at 10 A/28 V dc maximum. Delivery is from stock. Call for pricing.



NTE Electronics Inc.
44 Farrand St.
Bloomfield, NJ 07003
(201) 748-5089
▶ **CIRCLE 572**

▼ OPTO-ISOLATED RELAY PACKS FOUR CIRCUITS

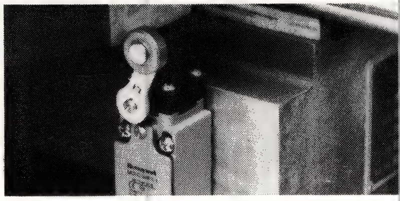
A four-circuit (Form A) general-purpose relay can switch ac or dc continuous currents up to 80 mA per channel (peak load current is 0.3 A). Dubbed the Multi-Channel Series, this addition to Aromat's PhotoMOS line offers pc-board space savings of over 50%. By optically isolating the input and output, the relays deliver 1500-V isolation. On resistances are under 50 Ω and off-state leakage is 1 μA maximum. There's no arcing, contact bounce, or noise, and the relays turn on in as little as 0.52 ms. Prices start at $14.65 in lots of 1000. Delivery is from stock to 16 weeks.



Aromat Corp.
629 Central Ave.
New Providence, NJ 07974
(908) 464-3550
▶ **CIRCLE 573**

▼ LIMIT SWITCH GOES MINIATURE

Miniature versions are now availab
of the GLS Series limit switch. Th
miniature EN50047 versions are o
fered in metal and double-insulate
enclosures. A metal-enclosed, thre
cable-entry version is also availab
and is the industry's only doubl



pole, three-conduit switch, it
claimed. More than 75 versions a
available including five basic switc
configurations, seven head style
and three body styles. List price
$24 in lots of 100 with delivery in
weeks.

Micro Switch
a Honeywell Div.
11 W. Spring St.
Freeport, IL 61032
(800) 537-6945
▶ **CIRCLE 574**

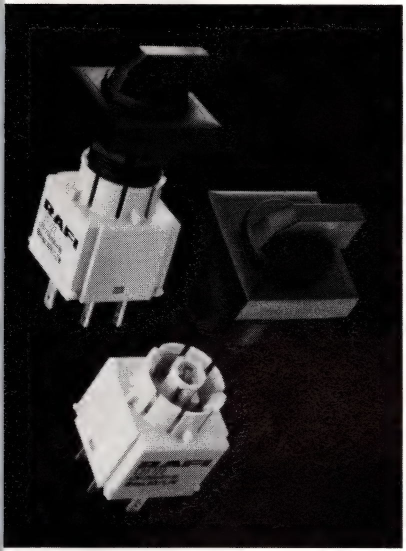
▼ SOLID-STATE RELAY SWITCHES UP TO 40 A

An answer to needs for higher cu
rent and voltage relays is found
the LR1200480D40 ac solid-state r
lays. The series uses the company
Powertherm process for better the
mal performance. Features inclu
back-to-back SCR output, IC-log
firing compatibility, and 4000-V is
lation from input to output. Rating
range from 240 to 480 V and from
to 40 A. Units are available for
control from 3 to 32 V, and offer zer
voltage switching. Units are also o
fered with ac control and rando
turn-on dc controls as well as tria
MOSFET-, and IGBT-based relay
The LR Series is also available
modular systems of from eight to
relays. Call for pricing.

Gentron Corp.
7345 E. Acoma Rd., Suite 101
Scottsdale, AZ 85260
(602) 443-1288
▶ **CIRCLE 587**

▼ LIGHTED SELECTOR SNAPS TOGETHER EASILY

n illuminated selector switch of- ers a snap-together design that al- ws for easy panel installation of e switch and lamp components. he RAFIX 16 switch features an in-

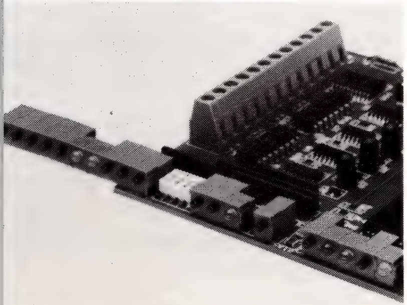


ernational-standard 16.22-mm-di- meter panel mount size. Momen- ary or latching functions, in a vari- ty of normally open and closed con- igurations, are available with atings from 5 A at 250 V ac with sil- er-plated contacts. Prices start at 25.17 in lots of 100. Delivery is from tock to 4 weeks.

C&K Components Inc.
Clayton/Unimax Div.
2035 Hwy. 70 East
Clayton, NC 27520-9058
(800) 334-7729
▶ CIRCLE 575

▼ STACKABLE SWITCH OFFERS CUSTOM CIRCUITS

oth SPST normally-open and SPST ormally-closed functions come in e same package in the Series 32-1

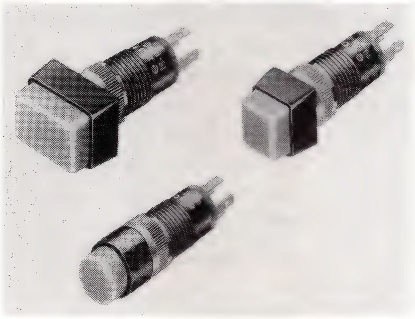


tackable pushbutton switch. SPDT unctionality is achieved by tying erminals together. Designed for pc- oard edge-mounting, the switch measures only 0.272 in. high by 0.220 in. wide by 0.400 in deep. An integral, interlocking mechanism permits switches to be stacked side by side. Prices are $1.37 in lots of 100 and $1 in lots of 1000. Delivery is in 2 weeks for prototype lots and 3 to 4 weeks for production lots.

Grayhill Inc.
561 Hillgrove Ave.
P.O. Box 10373
La Grange, IL 60525-0373
(708) 354-1040
▶ CIRCLE 576

▼ MINI PUSHBUTTONS MEET IP 40 SPECS

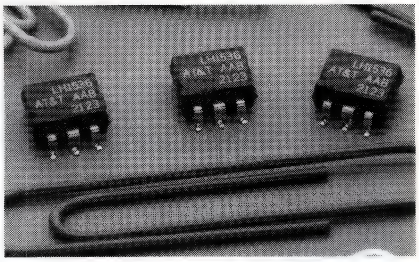
A general-purpose line of 9-mm illuminated pushbutton switches and indicators meets IP 40 specifications. The Series 18 miniature switching system features a minimum depth of 0.906 in. and is available in both maintained and momentary switching actions. Illuminated or non-illuminated rectangular, square, and round lenses are offered. LED illumination is integrated into lenses and indicators are supplied pre-assembled. The switches are rated at 100 mA at 42 V ac or dc. Pricing starts at $3.53 and delivery is from stock to 3 weeks.



EAO Switch Corp.
198 Pepe's Farm Rd.
Milford, CT 06460
(203) 877-4577
▶ CIRCLE 577

▼ HIGH-VOLTAGE SSR SUITS EURO-PHONE USES

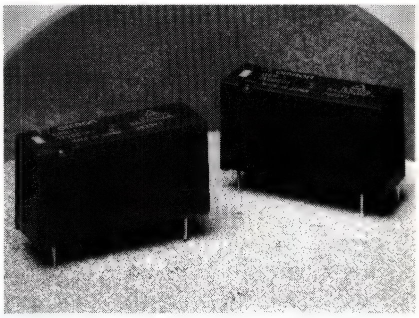
Exceptionally low on-resistance (4 Ω typical) gives the LH1536 solid-state relay compliance with European standards for parallel-phone applications. The 1 Form B (SPST) device provides a current capability of up to 600 mA and input-to-output isolation of 3750 V ac. In addition to general telecommunication applications, the LH1536 relay is suitable for industrial switching tasks where low on-resistance is required. The unit's double-molded package features superior environmental immunity. It's available in 6-pin DIP and gull-wing versions with UL recognition as well as CSA and BABT certification. In lots of 10,000, pricing is $3.16. Small quantities are delivered from stock.



AT&T Microelectronics
Dept. AL-500404200
555 Union Blvd.
Allentown, PA 18103
(800) 372-2447, ext. 899
▶ CIRCLE 578

▼ MINI RELAY MELDS LOW POWER, HIGH LOADS

Low power consumption is combined with high load capacity in a miniature power pc-board relay. The G6R relay features heavy-duty contacts that switch up to 8 A at 250 V ac. Its small size of 30 mm long by 10 mm wide by 15 mm high complements the design of high-density boards and helps cut the size of end products. The unit offers 8-mm spacing between coil and contacts and a 4000-V dielectric that meets European standards. Applications include programmable controllers, timers, counters, and other control systems for switching of contactors, servomotors, solenoids, motors, and other devices. Contact arrangements include 1 Form A and 1 Form C. Pricing is $2.67 in lots of 1000.



Omron Electronics Inc.
One E. Commerce Dr.
Schaumburg, IL 60173
(800) 62-OMRON
▶ CIRCLE 579

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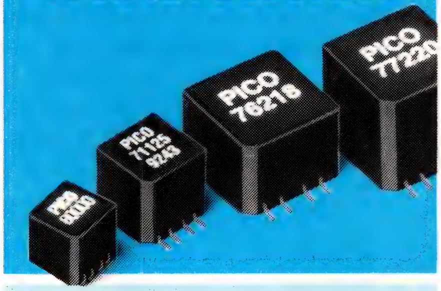

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PICO surface mount units utilize materials and methods to withstand extreme temperature (220°C) of vapor phase, I.R., and other reflow procedures without degradation of electrical or mechanical characteristics.

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PICO Electronics, Inc.
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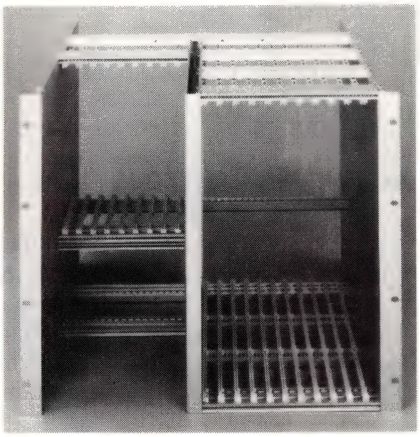
READER SERVICE 168

▼ RUGGED CARD CAGE MEETS MIL-STD-167

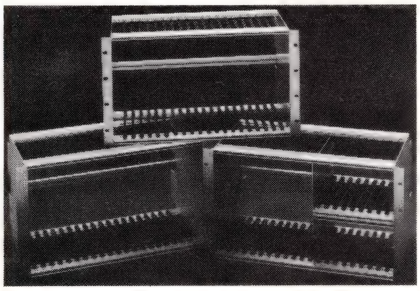
An off-the-shelf card cage that meets MIL-STD-167 requirements for shock and vibration is available. The HD-167 card cage features 1/8-in.-thick aluminum end plates, conductively finished heavy extrusions, and a built-in card-locking mechanism. Well suited for use in military and commercial environments, the cage comes in a range of standard sizes (available heights include 9U, 6U, and 3U) and accommodates all open-architecture bus structures such as VME, VXI, Futurebus+, and Multibus II. Pricing is $240 for a 6U-high unit.



BICC-Vero Electronics Inc.
1000 Sherman Ave.
Hamden, CT 06514
(800) 242-2863
▶ **CIRCLE 580**

▼ SUB-RACKS BOAST EUROPEAN STYLING

Encompassing all standard sizes and combinations of 3U, 6U, 9U, and 12U heights, the Euro packaging system from Electro-Space Fabricators features an easy method of specifying standard or custom VME and Multibus II sub-racks. The racks are made of rugged, stylized aluminum extrusions. All plastic components are molded of flame-retardant UL94V-O material. A card guide with molded-
in loop eliminates the need for ad
tional snap-in pieces in injector/eje
tor applications. Typical pricing fo
6U-by-220-mm enclosure is $80
$220 each, depending on quantit
Standard types deliver in two week
custom models in four.



Electro-Space Fabricators Inc.
300 W. High St.
P.O. Box 67
Topton, PA 19562-0067
(215) 682-7181
▶ **CIRCLE 581**

▼ FLEXIBLE COMPOSITES ARE OF ALL POLYIMIDE

A family of all-polyimide flexib
composites will find applications
military avionics, high-temperatu
sensors and probes, and under-th
hood automotive electronics. T
Pyralux AP family was developed
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als are particularly recommend
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above 200°C. Call for pricing.

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Barley Mill Plaza
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Wilmington, DE 19880-0010
(800) 237-4357
▶ **CIRCLE 582**

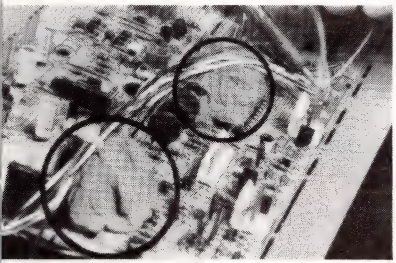
▼ SELF-RETAINING MOUNTS PUT LEDs ON TAPE

Designed to improve assembly a
elevation accuracy of T-1 and T-1-3
LEDs, the ELM Series of self-reta
ing mounts are available for ta
mounting of those components f
automatic insertion. Available
three styles, the mounts are firm
retained during handling and plac
ment onto tape reels. LEDs are th
able to be automatically inserted in
pc boards at desired elevations.
standard sizes are stocked in lengt
from 0.030 to 1.250 in. in 0.005-in.
crements. Pricing is typically $13.
in lots of 10,000.

Bivar Inc.
4 Thomas
Irvine, CA 92718
(714) 951-8808
▶ **CIRCLE 583**

MOLDABLE COMPOUND RESISTS HEAT

heat-resistant compound can be sed as a heat sink in electronic asmblies. The material, called Fla-

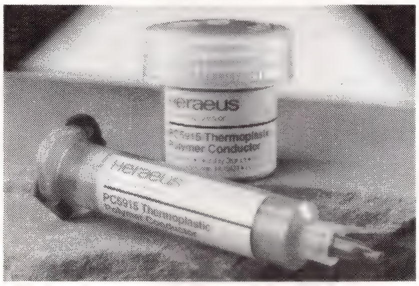


ehold, can be molded like clay to ke the place of costly machined fixres in prototype runs and will firmhold components in position for ldering. The material will withand the intense heat of wave solering and is dimensionally stable uring processing. A 5-lb. container es for $30.

Nassau Research Corp.
300 Corporation Dr.
Aliquippa, PA 15001-4865
(412) 375-3300
▶**CIRCLE 584**

▼ THERMOSETTING EPOXY HANDLES DIE ATTACH

A thermoplastic, silver-filled polymer conductive paste is intended for use in chip manufacturing and other surface-mount die-attach applications. The PC5915 epoxy's polymer formulation provides minimal void-



ing and is well-suited for reworking at low temperatures. Designed to be highly conductive, the material cures in just 10 minutes at 120°C.

Heraeus Inc.
Cermalloy Div.
P.O. Box 306
W. Conshohocken, PA 19428-0306
(610) 825-6050
▶**CIRCLE 585**

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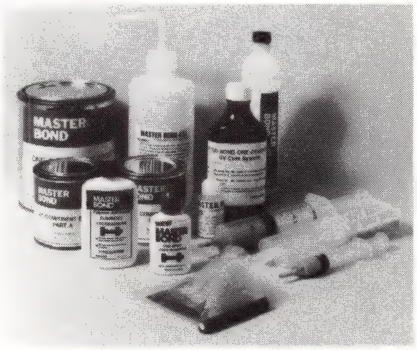

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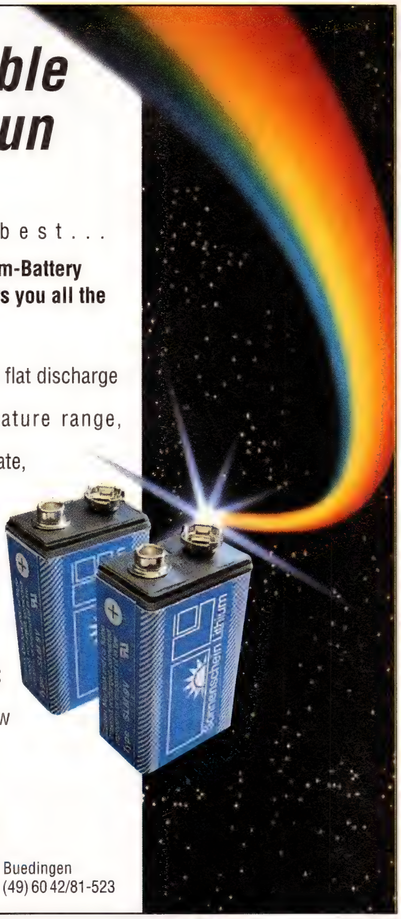

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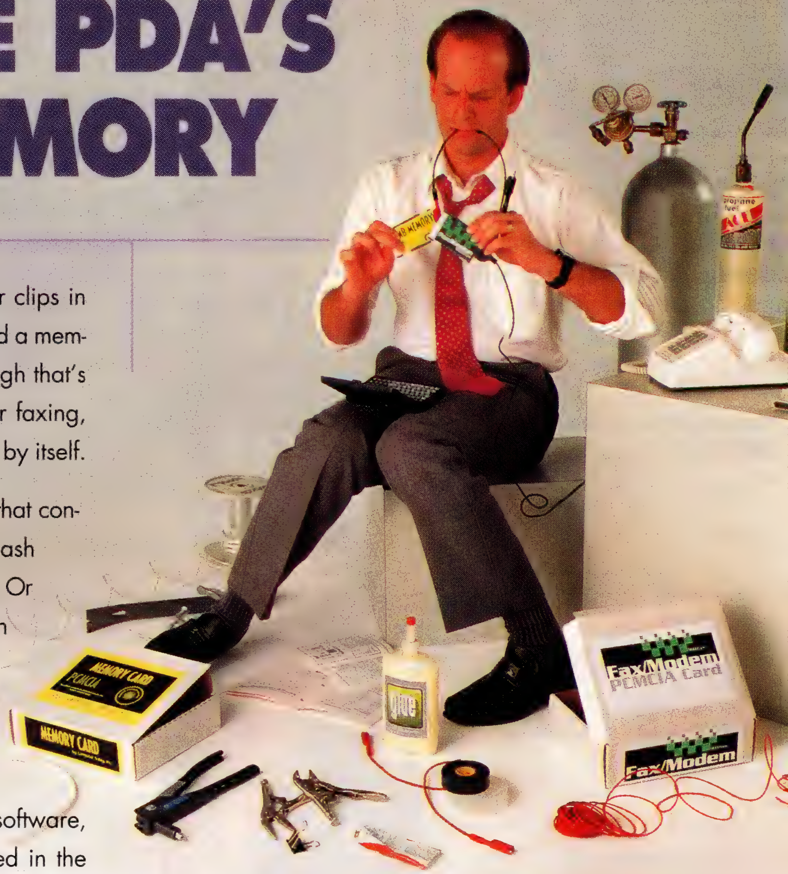
SOME PEOPLE GO TO EXTRAORDINARY LENGTHS TO GET A BIG FAX INTO A LITTLE PDA'S MEMORY



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LOW-COST TOOL AUTOMATES ASIC/ASSP PROTOTYPING

CHERYL AJLUNI

COMBO HARDWARE/SOFWARE PACKAGE GIVES ICDESIGNERS A HIGH-SPEED, REPROGRAMMABLE SOLUTION THAT BRINGS LOGIC TO LIFE.

Many prototyping challenges face today's IC designers. They include exhaustive system tests that overload current simulation-based verification solutions, faulty prototypes, and prototypes which arrive so late in the design cycle that schedules are jeopardized. Conventional prototyping systems, however, don't address these critical issues. Prototype development methods, such as "build your own" breadboards, also haven't the sophistication or automation to accurately prototype complex ASIC or ASSP designs.

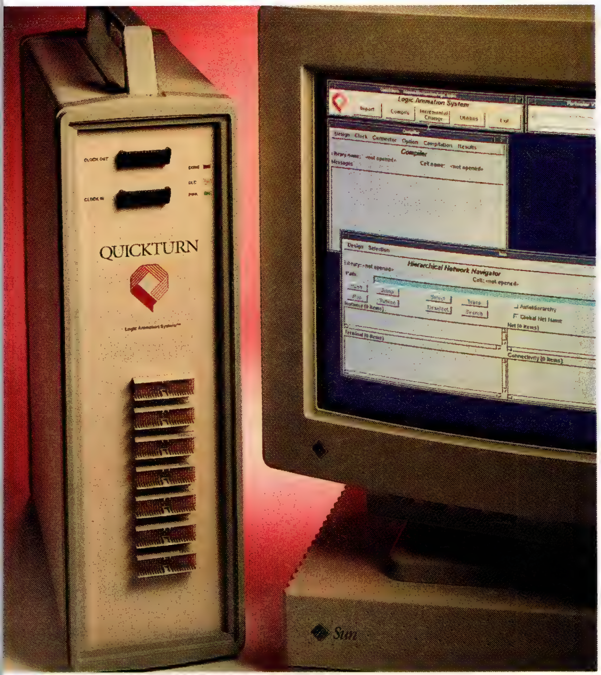
Consequently, many designers rely on alternate methods, such as multiple silicon spins for ASIC or ASSP prototypes. Yet even these are rought with potential problems. For example, if silicon is spun too early in a design, it's likely the prototype won't work. In fact, it's a rare event when all design bugs are worked out by the time the first prototype is fabricated. Unfortunately, if the prototype fails to operate properly, then it's quite difficult to perform an accurate evaluation and analysis. Thus, significant development time is wasted and delays are endured in critical time-to-market schedules. And, because the cost of this method often depends on the future business potential of an ASIC vendor, costs continually fluctuate.

Other conventional prototype development methods involve designers building their own breadboard s populated with TTL, or using breadboards populated with field-programmable gate arrays (FPGAs). Unfortunately, both of these methods have a common problem: The ASIC design must be partitioned to fit in the board and then the board must somehow be set up to accurately represent the ASIC design in the target system. The latter task alone can be quite difficult due to FPGA and ASIC architectural differences. Difficulty also arises in maintaining all of a device's timing characteristics. In addition, every design change requires another iteration of partitioning and mapping the design into a prototype board. Each iteration can take days or even weeks.

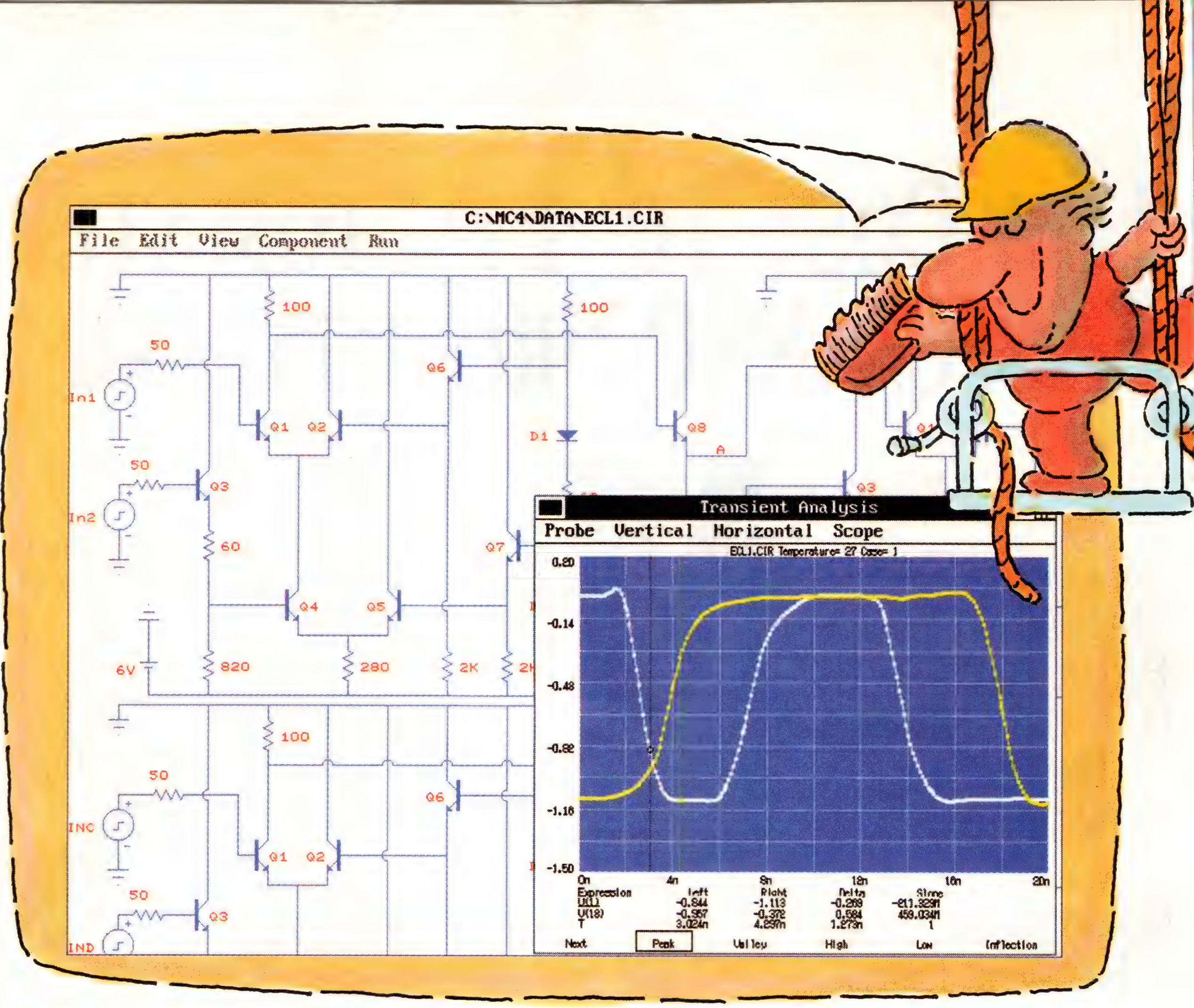
To unknot this tangle of prototyping problems, Quickturn Design Systems developed the Logic Animation System (LAS). With automatic creation of reprogrammable prototypes, the LAS allows the successful design and implementation of ICs under 50,000 gates in their target systems, for first-time silicon *(Fig. 1)*.

By creating a new class of ASIC design tool, Rapid Prototype System, LAS can produce an accurate representation or prototype of an ASIC design. The representation, often referred to as a virtual silicon prototype, can then be analyzed, evaluated, and incrementally changed to extract the optimum performance out of the design. The complex nature of the LAS software and associated critical algorithms assure a "correct-by-design" prototype in one pass.

The primary benefit of LAS is its quickness and accuracy in creating a



1. THIS COMBINATION hardware/software system developed by Quickturn Design Systems, called the Logic Animation System, allows the successful design and implementation of ASICs and ASSPs. Up to 50,000 gates are used in their target systems.



```
Expression      Left      Right     Delta      Slope
V(1)           -0.844    -1.113    -0.269   -211.329M
V(18)          -0.957    -0.372     0.584    459.034M
T               3.024n    4.297n    1.273n        1
```

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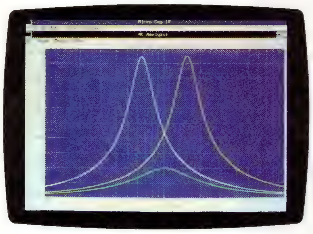

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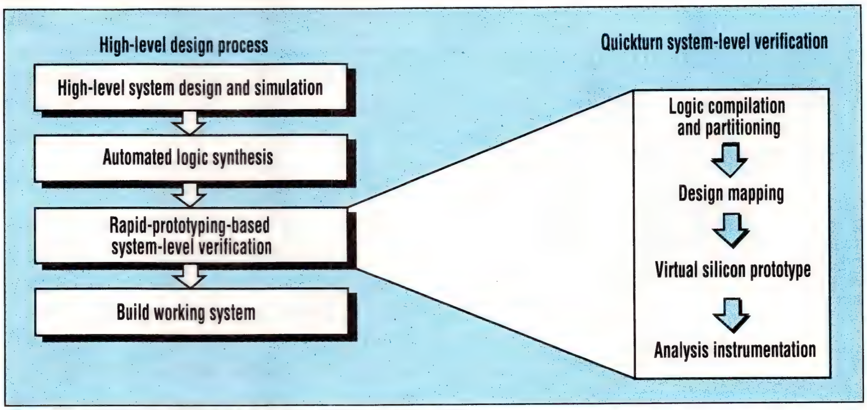
prototype. In as little as one week, the LAS can provide the same, if not better, results than those arrived at after many months using conventional prototyping. Designers now have at their disposal a rapid prototype that's not a silicon chip, but rather a reprogrammable system with the same functionality as the final ASIC.

LAS consists of a software package that has single-pass automatic compilation, "correct-by-construction" timing, interactive speed optimization, and incremental probe changes. The hardware package includes a board and power supply that fits in an enclosure 18.5 in. high by 16 in. deep by 6 in. wide and weighs about 15 lbs. The board has 448 bidirectional signal pins, about 200 of which are allocated to the ASIC pins; all others are used for the logic analyzer connections.

The LAS cleverly integrates new technologies, such as critical circuit logic with extra software refinements in a fully automated system. Though constructed with very complex components, the design methodology from a user standpoint typifies overall system simplicity *(Fig. 2)*. In fact, it's been estimated that a new user could take a design to prototype in less than a week, with almost no learning curve.

Unique to its single-board architecture, LAS prototypes are expected to operate at 8 to 16 MHz. This is significant since Quickturn emulation systems offer speeds of only 1 to 4 MHz. The high speeds allow the system to interface to mechanical devices, such as disk and floppy drives, plus other network interfaces without complex slowdown issues. The speeds are achievable, in large part, because of the advanced system architecture and innovative software package. Composed of three key sections—prototype, high-speed I/O, and clock logic—the LAS provides the fastest method available for prototyping a system.

Clock skew among logic elements is minimized by the clock logic chip and clock signal distribution. The logic works to actively analyze each clock tree in a design input. Once analyzed, any differences between the timing characteristics of the initial input design and those of the LAS are identified to ensure a functionally equivalent prototype. In this manner, timing-critical paths are optimized for maximum speed. Moreover, with the help of a critical algorithm, the clock logic increases prototyping speed, making theprototype speed as close as possible to the target system.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High-level system design and simulation
Automated logic synthesis
Rapid-prototyping-based system-level verification
Build working system
Quickturn system-level verification
Logic compilation and partitioning
Design mapping
Virtual silicon prototype
Analysis instrumentation

2. THE DESIGN METHODOLOGY of the Logic Animation System illustrates how the system easily fits into the overall design cycle.

The high-speed I/O logic also serves a fundamental purpose in achieving the highest possible prototyping speed. Here, automatic path-oriented partitioning takes place. Each data path is treated as a single unit and each unit interfaces directly with the outside. This maximizes speed by placing all timing-critical paths in the high-speed I/O logic. And by clustering logic elements in a single chip, the lengthy hops between them are eliminated. Such hops will otherwise slow down the system considerably.

The rapid prototype process begins when design data is initially input into the Logic Animation Software (in standard EDIF, NDL, TDL, or Verilog formats from all of the major EDA environments) on a workstation. Once compiled, the ASIC design is automatically partitioned, with the help of the Quickturn-developed software, and mapped. A memory compiler automates on-chip RAM and ROM mapping into programmable logic. All of this is done in a single pass with accurate timing. At this stage, users can start design debugging by connecting one of many compatible commercial logic analyzers to the LAS.

During these three steps—compilation, partitioning, and mapping—any number of complex functions are taking place. For example, once the design is compiled, design feedback, in the form of a back-annotated net list of delay data, is provided to act as a guide in improving the prototype speed and capacity.

In many cases, IC designers wish to boost the performance of their design by making changes in high-level design constraints, such as the placement of nets, devices, and instances in the high-speed I/O logic, just to name a few. Using the LAS, these changes are easily completed through a type of interactive speed-optimization iteration. A second type of interactive speed optimization, which takes place once the design is compiled, allows the net list obtained from design feedback to be fed into the preferred simulation environment to optimize the timing. This iteration is an easy way to debug a design for any potential problems.

The LAS was specifically developed for use on virtually all digital ASIC and ASSP designs under 50,000 gates. Yet, it also can handle larger designs using random logic and standard logic cores or macrocells. In such a case, the standard core logic would be placed on the system's External Interface Module. It's then possible to prototype the custom logic around the core within the FPGAs. Thus, the LAS could effectively handle an IC design with up to 50,000 custom gates and any number of cores.

In the first phase Quickturn's three-phase approach to fast, low-cost prototyping, a user can effectively take the IC design, using the methods described, to prototype in less than one week at minimal cost. With the help of commercial logic analyzers connected to the LAS via the External Interconnect Module, the prototype can then be debugged in its target environment. When the design is stable, the designer has achieved a "golden

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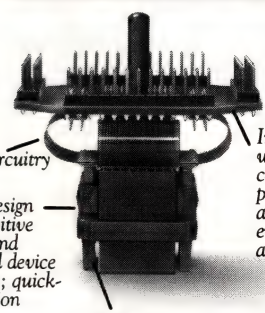
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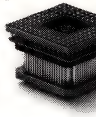

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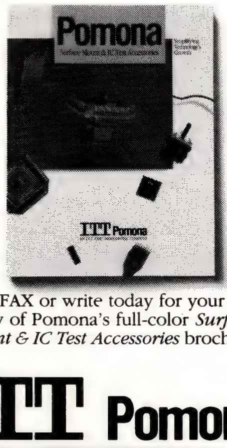

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model" prototype. This model can then be used in a variety of development and test functions. In effect, this guarantees that the model plugged into the ASIC socket in the target system will function as if the ASIC itself were plugged in.

Phase two focuses on the distribution of the "golden model" prototype to other team members via a floppy disk, Internet, e-mail, or other communication network. This allows all members to work on the system concurrently, prior to any silicon being available and before any ASIC NRE dollars are spent, noting any necessary changes. All required changes can be made easily and quickly, often in a matter of minutes, by downloading new versions of the "golden model" from a personal computer with data distributed on a floppy disk. This process provides for further debugging and optimization of the IC design during the software development systems integration and test phases.

The third phase focuses on the distribution of low-cost, fixed-interconnect copies of the prototype. These copies are made from the "custom prototype" option within the LAS software, and is invoked only after the design is finalized. All information needed to develop fixed-connection pc-board or wire-wrap versions of the prototype, such as a timing-correct net list and FPGA programming data, is provided by this software option. Copies may be distributed in large volumes for beta testing or other related purposes at a fraction of the cost of the reprogrammable prototype. ☐

PRICE AND AVAILABILITY

The LAS software for Sun SPARC stations and hardware will begin beta testing in the second quarter. Production volumes will start shipping in July. A single-user floating license is available for $60,000, with each hardware copy priced at $30,000. In addition, an annual maintenance price of 12% of the combined hardware and software price will be charged. Special volume discounts are available.

Quickturn Design Systems, Inc., 440 Clyde Ave., Mountain View, CA 94043-2232; (415) 967-3300. CIRCLE 513

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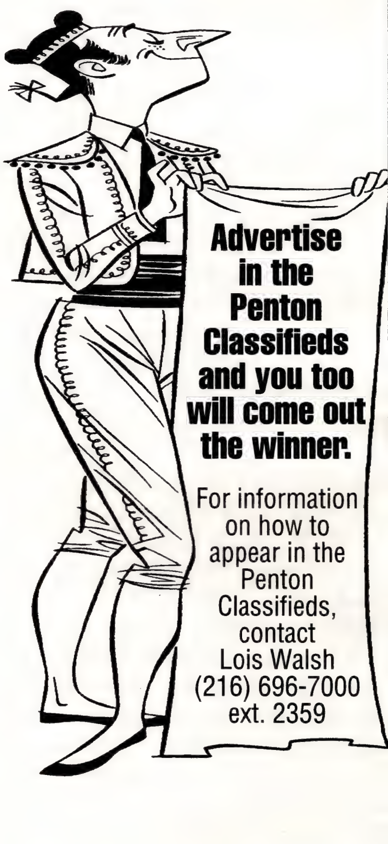

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PRODUCTS NEWSLETTER

PLD AND FPGA DESIGN TOOLS MOVE TO WINDOWS

An agreement between Intel Corp., Folsom, Calif., and Viewlogic Systems Inc., Marlboro, Mass., yields a PC-based CAE package for PLD and FPGA design that runs under Windows. Intel is licensing the Viewlogic PRO Series Windows software to use in its PROiDesign system for the design of any of Intel's programmable-logic devices. PROiDesign is an integrated environment consisting of a number of Viewlogic modules—behavioral and schematic-capture design entry, functional and timing simulation, and VHDL-based analysis and logic synthesis. Intel's own place-and-route fitter and programming capabilities also are included. Pricing for the tools starts at less than $2000. Call Intel at (800) 628-8686 or (916) 356-8080 for more information. *LM* **CIRCLE 590**

SPICE SIMULATOR JOINS WINDOWS-BASED TOOLSET

PROspice, a fast analog circuit simulator, is the latest addition to the Windows-based EDA toolset from Viewlogic Systems Inc. The simulator is based on the 3F2 Berkeley Spice technology, yet maintains full compatibility with earlier Berkeley Spice versions. PROspice has 64-bit precision, which yields both accuracy and speed. Other features include behavioral modeling, lossy-transmission lines, and LaPlace transforms. PROspice supports statistical modeling using the Monte Carlo technique and worst-case analysis. In addition, the simulator comes equipped with an integrated waveform analyzer, and a modeler that works from databook information. PROspice is available now as a standalone module for $3995. PROanalog solution, which costs $6495, bundles the simulator with a schematic and symbol editor, and a software link for connecting to other Spice-based simulators. For more information, call (508) 480-0881. *LM* **CIRCLE 591**

HDL SYNTHESIS AIMS AT FPGA FUNCTION MODULES

The X-SYN synthesis tool from Compass Design Automation Inc., San Jose, Calif., lets engineers create FPGAs using HDL-based, top-down techniques that target high-level function modules for the Xilinx XC4000 device family. This approach can shorten design-cycle times and maximize chip utilization and performance. X-SYN leverages Compass' existing ASIC-datapath synthesis technology for FPGA design. Prior to the introduction of X-SYN, engineers using the Xilinx libraries have relied on manual installation of X-BLOX modules and hard macros in their HDLs to create chips. X-SYN accepts both VHDL and Verilog input, and then automatically infers datapath elements and directly maps them to parametrized modules. Engineers can simulate their entire design at the behavioral level without requiring simulation models for X-BLOX modules. X-SYN is available now as an option to the company's ASIC Navigator design tools, which run on HP and Sun workstations. It costs $15,000. Call (408) 433-4880. *LM* **CIRCLE 592**

FIBRE CHANNEL COMES TO S-BUS COMPUTERS

SBus-based computer users can now enjoy the high data rates offered by Fibre Channel technology by using an adapter card, which permits transfers at up to 100 Mbytes/s between peripherals or other workstations. The FC 266/1062 card, offered by Jaycor, San Diego, Calif., occupies two SBus slots and has a fiber optic interface, which supports 1/4 and full-speed ANSI Rev. 3.0 Fibre Channel communications for all service classes, including Class 1, 2, and 3 intermix modes. Targeted initially at workstation cluster applications, such as finite element analysis and geophysical computations, the board will permit several workstations to share large data files as they work concurrently. Software to support more traditional LAN applications is under development. A TCP/IP driver, which runs under Solaris 2, will be available in July, with drivers for Direct Channel and SCSI to follow later in the year. The initial price is $5000, with a low-cost single-slot version anticipated in late 1994. Contact Terry Parrish at (619) 535-3174. *LG* **CIRCLE 593**

SOFTWARE PROBE DEBUGS BDM TARGETS

A software probe aimed at systems using the Motorola Background Debug Mode (BDM) attaches easily to the target system and makes many of the measurements needed by software developers for in-target debugging. The HP E3490A, which is easier to connect to the target and to use than traditional emulators, supplies run control, memory modification, and code downloading. Unlike ROM monitors, the software probe continues to run if the target system crashes, so designers can continue debugging or investigate the cause of the crash. Interfaces are available to connect the probe to Unix-based workstations or IBM PC-compatibles running Windows. The probe can be combined with HP logic analyzers for full-featured software debugging. The HP E3490A costs $3995, with delivery in 12 weeks. The Unix interface costs $3585 and the PC probe is $1750. A single-user license for the HP B3740A software analyzer costs $1400. For information, call (800) 447-3282, or fax (719) 590-5054. *JN* **CIRCLE 594**

REDUCED SUPPLY VOLTAGE TRIMS PEEL POWER DRAIN

A low-voltage PEEL programmable logic device, the PEEL18CV8L, developed by American Microsystems Inc., Pocatello, Idaho, can operate from a 3-V power supply while typically drawing just 5 mA. The electrically erasable chip includes circuits to minimize susceptibility to noise, and the flexibility of the on-chip macrocells lets the one device replace any of 20 different 20- or 24-pin PLDs. The device will sell for $1 each in lots of 10,000 units. In addition, AMI also released a 5-V chip, the PEEL22CV8, which the company expects will be a low-cost replacement for the Lattice GAL20V8 chip, yet offer more flexibility and two additional input pins. The 22CV8 will sell for between $0.60 and $3, depending on the speed grade and quantity. *DB* **CIRCLE 595**

LOW-VOLTAGE COMES TO EPROM AND FUSE PLDS

Low voltage will also be the highlight of the P3C18V8Z35 and ZI, 20-pin zero-standby-power PLDs developed by Philips Semiconductors, Sunnyvale, Calif. The EPROM-based chips are available as either reprogrammable units in windowed packages, or one-time programmable versions in plastic packages. Aimed at moderate-performance applications, the chips have input-to-output delays of about 35 to 40 ns, but draw just 20 μA on standby, and 0.8 mA/MHz when active (with a 3.3-V supply). For higher-performance applications, Philips is readying two additional chips, both of which will be fabricated in a high-performance metal-fuse biCMOS process. The first chip is the LVT22V10-10, a 10-ns, 3-V version of the 22V10 PLD, which dissipates about 500 mW and is being sampled now. Slated for release next year is the LVT20V8-7, a 7.5-ns, 3-V chip that is architecturally similar to the Lattice GALs. The LVT20V8 will dissipate about 300 mW. *DB* **CIRCLE 596**

ENHANCED 5-V PLDS CONSUME LITTLE POWER

Although they didn't use a low-voltage supply, designers at Atmel Corp., San Jose, Calif., found an approach that trims the standby current of its ATV2500B, a 44-pin high-density PLD, to just 2 mA. The chip contains 24 flexible macrocells that each have 17 product terms and are globally connected by a single AND/OR matrix. Each macrocell has two flip-flops that can be configured as either D or T type. *DB* **CIRCLE 597**

PLDS GAIN TEST PORT TO EASE SYSTEM TESTING

The use of JTAG test ports on VLSI chips has been accelerating, but at the board level, test engineers have been stymied by the lack of JTAG-compatible moderate-density logic. Now, Advanced Micro Devices Inc., Sunnyvale, Calif., and National Semiconductor Corp., Santa Clara, Calif., have unveiled both a complex PLD and a 22V10 equivalent, respectively, with JTAG test ports that also permit in-circuit programming. The AMD Mach445 combines JTAG testing and 5-V in-circuit programming of its EEPROM configuration cells. This allows designers to string together several devices in addition to the VLSI chips on the board, and program the devices in the system. Consequently, designers can set up special test patterns during board-level diagnostics, which otherwise would not be possible if the programmable chips were not in-system configurable. The company also plans to release the Mach355 and Mach465—smaller and larger Mach family members with JTAG ports. The Mach445 provides about 5000 equivalent gates with 128 macrocells, 64 I/O lines, and 100 pins, and sells for $45.65 apiece in 100-unit lots.

National's smaller 22V10 replacement, the SCAN22CV10, provides scan-based test capability for the most popular PLD architecture. The chip is basically a 22V10 with hardwired JTAG support, using the four no-connect pins of the PAL and GAL22V10 PLCC package option to provide the four test-port signals. Also implemented in a CMOS EEPROM process, the chip can be programmed and erased a minimum of 100 times. But unlike the AMD chip, the 22CV10 requires the use of the standard 22V10 programming levels. Versions of the SCAN22CV10 are available with input-to-output delays as short at 10 ns. In lots of 1000, the chip sells for $9 each. *DB* **CIRCLE 598**

Edited by Clifford Meth

The products listed are available in Europe but may not be available in other market areas of the world.

TEST KITS FOR LAN/FDDI

The OMK-8 and -10 Fiber-Optics Test Kits are powerful yet economical tools for measuring levels and attenuation on LAN and FDDI systems with multimode fibers. For applications in the 850-nm range, the OMK-8 kit includes the OLS-8 Optical LED Source (850 nm) and the OLP-10 Optical Power Meter. OMK-10 contains the OLS-10 Optical Led source (1300 nm), as well as the OLP-10. Consequently, it is suitable for testing 1300-nm multimode systems (such as FDDI). Given the output level and display range of these instruments, a dynamic range of > 50 dB is possible when measuring attenuation. To identify fibers on the RX end, the output signal can be modulated at 270 Hz, 1 kHz, or 2 kHz. The receiver then recognizes and displays the modulation frequency. This significantly reduces the risk of confusing fibers. The instrument and accessories are housed in a rugged, splash-proof hardshell case. The OMK-8 and -10 also include one of the company's test adapter each for the generator and receiver, four NiCd cells, and an ac adapter/charger. The carrying case also has room for other accessories (such as test adapters, couplers, and cables). CM

Wandel & Goltermann GmbH & Co.*, P.O. Box 1262, D-72795 Eningen u.A., Fed. Republic of Germany.* **CIRCLE 938**

CAD TOOLKIT HELPS RF ENGINEERS

The paper Smith Chart, invented over 50 years ago, provides a graphical method for solving impedance matching and transmission line problem. The Z-Match for Windows program greatly enhances the usefulness and accuracy of Smith Chart techniques, and adds a wide range of valuable radio-frequency engineering utilities.

Z-Match for Windows provides RF and communications engineers with a comprehensive set of circuit and system-design tools in an easy-to-use, low-cost package. The toolkit works directly with actual lengths of transmission line, and actual resistance and reactance values, eliminating the need for normalization.

Engineers can also switch instantly between impedance and admittance charts. Direct readout from the chart gives immediate measurement of impedance or admittance parameters, equivalent component values, SWR, Q factor, and reflection coefficient.

Circles of constant SWR, resistance, conductance, and reactance can be drawn automatically. Z-Match for Windows also provides a receiver and system-design tool for calculating overall values of gain, noise figure, and third-order input intercept point for a series of interconnected stages made up from filters, amplifiers, mixers, and attenuators. CM

Number One Systems Ltd.*, 1 Harding Way, St. Ives Huntingdon, Cambs., PE17 4WR, England.* **CIRCLE 939**

ANALYZER ADDS COLOR, PERFORMANCE

The DA-30C, a color-display protocol analyzer based on the DA-30 Internetwork Analyzer, incorporates the modular architecture of the DA-30 and adds the high-performance hardware necessary to handle a graphical user interface easily. The new analyzer can run either the company's original character-based interface or its new DA-30 for Windows interface in up to 4096 colors.

The central processing unit is powered by a 486SX/33-MHz CPU with built-in cache. The CPU also features 8 Mbytes of random-access memory (RAM) for running memory-intensive software. To avoid the video-processing bottleneck common to graphical-user interfaces, the DA-30C analyzer employs a 32-bit local bus video.

The DA-30C comes in a rugged, cast-aluminum case. The hard drive (120-Mbyte standard) is the same type used in notebook and laptop computers. Because navigating the DA-30 for Windows interface requires a pointing device, a trackball is built into the keyboard. Any standard external mouse can also be used. CM

Wandel & Goltermann GmbH & Co.*, P.O. Box 1262, D-72795 Eningen u.A., Federal Republic of Germany.* **CIRCLE 940**

TCXOS FOR DIGITAL RECEIVERS

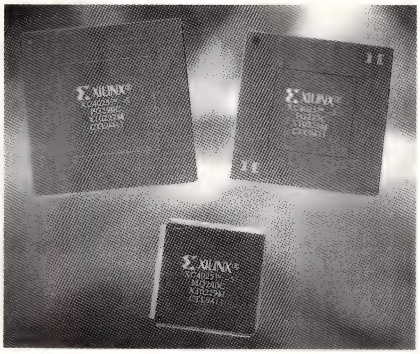
Low-phase noise TCXOs come in standard frequencies of 32 MHz and 8 MHz for use in GPS and NAVSTAR receivers. Other frequencies are also available.

The oscillators feature a small 20-by-20-mm enclosure. They also have an internal temperature sensor with analog and two cophasal outputs. Additional performance advantages include extremely low vibration and microphonics sensitivity. CM

Tele Quarz GmbH*, Landstrasse, D-74924, Neckarbischofsheim, Germany.* **CIRCLE 941**

RAM-BASED FPGA PACKS 25 KGATES, 256 I/OS

Raising the density limits for monolithic RAM-based field-programmable logic chips, the XC4025 packs a usable gate count of 25,000 gate equivalents. That complexity level is 78% higher than the company's previous high-density offering, the XC4013. The XC4025 also offers 33% more I/O resources, with a maximum of 256 I/O pins. In all, there are 1024 configurable logic blocks on the array, a total of 2560 flip-flops, and 32,768 bits of RAM. With those resources, the chip can implement 102 instances on an average of nine benchmarks, as specified by the benchmark tests developed by the PREP Co., Los Gatos, Calif., benchmark organization—the highest instance count to date for SRAM-based FPGAs.



The high density of the XC4025 allows designers to implement complex functions and achieve high speeds. The 0.6-μm minimum features used to implement the array keeps the logic block delays short—just 4.5 or 6 ns, depending on the speed grade selected. An even faster version will be available by late this year. The architecture of the XC4025 is basically the same as the other XC4000-family members—it includes the ability to use the memory in the configurable logic blocks as RAM, dedicated hardware support for arithmetic carry logic, wide decoding logic, eight global clock nets, and boundary-scan test circuitry.

In lots of 100 the XC4025 will sell for $654 each (the XC4025-6MQ240), when housed in a 240-lead metal quad-sided flat package. The array is also available in a 223- or 299-lead pin-grid array package. In the second half of this year, the array price will approach $400 in volume.

***Xilinx Inc.,** 2100 Logic Dr., San Jose, CA 95124; Mark Gohr, (408) 559-7778.* **CIRCLE 605**

■ *DAVE BURSKY*

MULTISTANDARD CHIP SET FOR BROADCAST AND CONSUMER APPLICATIONS DECOMPRESSES VIDEO

With the ability to decompress video data from any of four formats, the CL9100 decompression chip, and the companion CL9110 transport demultiplexer IC, allow designers to build flexible set-top boxes that also include the General Instrument Digicipher security. The RISC-based CL9100 can decode video signals that conform to the MPEG II main-level, main-profile standard, as well as video signals that conform to the MPEG II main-level simple profile standard. The chip set also supports video signals conforming to the Digichiper II and MPEG I encoded video standards.

Armed with the multimode capabilities, the chip set can handle a wide range of applications in both broadcast and consumer systems. Additional support on the chip includes the ability to handle NTSC, PAL, and film video standards, as well as support for multiple video resolutions.

The CL9100 decompression chip handles video streams at rates up to 15 Mbits/s. It also provides on-screen display capabilities, advanced error concealment, and a high-level command-based host-computer interface.

Supporting the CL9100 is the CL9110 transport demultiplexer IC. It implements the MPEG II transport-layer demultiplexing functions. Also employing a programmable RISC processor architecture, the 9110 processes the transport and packetized elemental stream (PES) layers of the MPEG II standard and delivers elemental video, audio, and host data streams.

The CL9110 transport demultiplexer handles channel rates of up to 60 Mbits/s, as well as customer-specific descrambling algorithms through an external interface. To round out the chip set, an external MPEG audio decoder must be added to generate the sound track.

With just 16 Mbits of DRAM to support the decompression, a subsystem can be implemented to handle all algorithmic options, while an 8-Mbit design supports MPEG I and MPEG II (main-level, simple-profile), and Digicipher II. All MPEG frame types—I, P, and B frames in main-profile mode, I and P only in simple mode with enhanced prediction—are also supported by the chip set. The chip set handles upsampling from all input resolutions to full CCIR 601 resolution video of 720-by-480 pixels at 30 Hz (NTSC), or 720-by-576 pixels at 25 Hz (PAL).

The chip set can display video in byte-wide CbYCrY format at 27 Mbytes/s. It can also provide pan and scan for 16:9 source material, supply presentation time stamps, support time-base correction, and conversion from film-source inputs to video frame rates using 3/2 pulldown for 24- to 30-frame/s conversion for NTSC, or 1/1 pulldown for 24-frame/s to 25-frame/s conversion (PAL).

Samples of the CL9100 are now available in 160-lead PQFPs. In volume, the CL9100 will sell for $35 each. Housed in a 208-lead PQFP, the companion CL9110 will sample in the third quarter. In volume, it will sell for $35 each.

***C-Cube Microsystems,** 1778 McCarthy Blvd., Milpitas, CA 95035; Alex Balkanski, (408) 944-6300.* **CIRCLE 606**

■ *DAVE BURSKY*

T adds the Quarter-Size Outline ackage (QSOP) to complete its inning hand of surface-mount ackages for its high-speed FCT gic family. With products availle in TSSOP, QSOP, SSOP, and andard SOIC packages, IDT now fers the industry's widest line of igh-density packaging for both ctal and Double-Density logic.

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half the length and width industry standard SOIC ckages, the new QSOP ckage is the most compact ctal package available. In dition to the area savings, e new package is only 0645 inches high, making it eal for low profile applications.

The Fastest 5V and 3.3V Logic

IDT's Logic family is the highest performing, lowest power bus interface solution. Available in a wide variety of 5V and 3.3V functions, and speed grades from 6.5ns to 3.2ns (t_{pd} max), IDT's FCT Logic family supports all levels of performance at competitive prices.

Quiet, Low-noise Outputs

IDT's FCT Logic is offered in a variety of low-noise output drive configurations to minimize ground bounce and to match specific design requirements. Output configurations include: standard TTL-compatible high drive and very low-noise balanced drive with source terminating resistors.

Compact IDT FCT Logic Packaging

Package	Ordering Code	Pin-Pitch (mm)	Area (mm²)	Length (mm)	Width (mm)	Height (mm)
QSOP 20-pin	Q	0.635	52.1	8.7	3.9	1.6
SSOP 20-pin	PY	0.650	56.0	7.2	5.3	1.9
SOIC 20-pin	SO	1.270	133.1	12.8	7.5	2.5
TSSOP 48-pin	PA	0.500	102.1	12.6	6.2	1.1
SSOP 48-pin	PV	0.635	164.4	15.9	7.5	2.6

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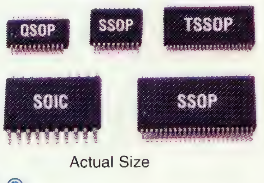

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Integrated Device Technology, Inc.

READER SERVICE 156

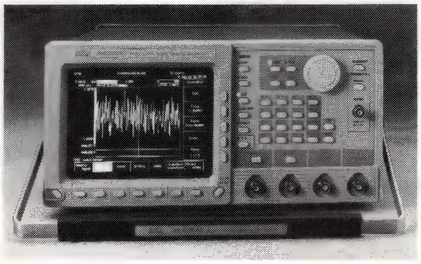
ARBITRARY GENERATORS BOAST EASY-TO-USE EDITING CAPABILITIES

A pair of arbitrary waveform generators offer high performance and a very easy-to-use interface. Operators can choose from seven waveform editing capabilitites, all self-contained within the instruments.

The AWG 2040 features 1-Gsample/s sampling and up to 4 Mbytes of memory, which will permit accurate definition of the complex waveforms needed to test advanced systems. The AWG 2005, which samples at 20 Msamples/s and has 64 Mbytes of memory, comes with from one to four channels of phase-coherent analog output.

Waveform entry methods include:

- graphical, which is similar to PC-based drawing programs that use procedures like copy, paste, invert, clip, and scale
- direct transfer, which allows signals captured on digital scopes to be transferred to the generator
- timing and table editing, which lets users edit signals in binary, hex, or decimal format
- FFT, which allows users to view and edit waveforms in the frequency domain as well as the time domain
- equation editing, which creates waveforms based on polynomials entered by the user
- sequencing, which allows users to create a waveform by connecting waveform segments
- standard waveforms in a built-in library.



Options include up to 12 bits of ECL or TTL digital output, which is helpful in mixed-signal characterization of logic circuits. Also, the optional WaveWriter software package provides all seven waveform editing capabilitites on a PC. The resulting waveforms can then be downloaded to the generators.

Prices for the AWG 2040 and AWG 2005 start at $19,995 and $9995, respectively.

Tektronix Inc., *Test and Measurement Group, P. O. Box 1520, Pittsfield, MA 01202; (800) 426-2200.* **CIRCLE 607**

■ *JOHN NOVELLINO*

RUN REAL-TIME DATA PROGRAMS IN WINDOWS

The DAPwindows software system allows users to develop and run high-performance real-time data-acquisition systems under Microsoft Windows without doing any Windows programming. The system works with the Data Acquisition Processors (DAP) line of products, which come with DAPL, a dedicated multitasking real-time operating system that runs on the DAP's own processor and communicates with software running on the host PC under Windows. Users click on icons to program the system by performing tasks such as creating a new DAPL command list, which defines what the DAP must do for the specific application. Results can be presented in any number of display windows in the form of graphs, indicators, digital meters, or tables. DAPwindows costs $295 and is available for immediate delivery. JN

Microstar Laboratories Inc., 2265 116th Ave. N.E., Bellevue, WA 98004; (206) 453-2345 **CIRCLE 608**

WINDOWS-BASED ATM TESTER WORKS WITH PC

The TST-ATM turns a PC into a comprehensive, interactive ATM tester for laboratory or manufacturing test. The system consists of a control unit, an interface module that contains the WAC-013-A Sonet ATM UNI processor, and a Windows-based software package. Interfaces are available for STS-1 multimode, STS-3c multimode, STS-3c single mode, DS3 (future), ES (future), and other standards. In the transmit direction, the TST-ATM sends alarms and generates errors. In the receive direction, the unit detects alarms, counts errors, and captures and counts cells based on several capture options. A 512-cell buffer permits long-term testing. TST-ATM prices start at $9000. JN

Integrated Telecom Technology Inc., 18310 Montgomery Village Ave., Suite 300, Germantown, MD 20879; (301) 990-9890 **CIRCLE 609**

ISOLATORS ENSURE SAFE MEASUREMENTS

The A6905S and A6906S fiber-optic isolation systems allow users to safely measure floating high-voltage signals with fast edges. The systems consist of a specially designed floating probe rated for 850 V, a battery-powered transmitter unit, up to 200 m of fiber-optic cable, and a receiver unit. The A6906S has a 100-MHz bandwidth, 100,000-V/μs slew rate, manual or IEEE-488 control, and a common-mode rejection ratio of 120 dB at dc. The A6905S is a dc-to-15-MHz unit that handles slew rates to 10,000 V/μs. It offers attenuations of 10X, 100X, or 1000X and cable lengths of 3, 15, 50, and 100 m. The A6905S cost $2695 and the A6906S is $6750. Delivery is in four weeks. JN

Tektronix Inc., Test & Measurement, P. O. Box 500, Beaverton, OR 97077; (800) 426-2200 ext. 215 **CIRCLE 610**

188/186 EMULATOR GETS REAL-TIME EVENT SYSTEM

Several features have been added to the PathFinder, a low-cost in-circuit emulator for the 188/186 family of processors. A new real-time bus event system can break or trigger trace collection. The system matches the processor bus against user-supplied parameters. Users can set "don't cares" in any bit position, so partial matches can be created. Complex breakpoints of up to five levels deep are also possible. The PathFinder comes with SLD for Windows, a source-level debugger. A DOS-based version is also available. The PathFinder costs $4995 and is available from stock. JN

Softaid Inc., 8310 Guilford Rd., Columbia, MD 21046; (800) 433-8812 or (410) 290-7760 **CIRCLE 611**

ELECTRONIC DESIGN'S

1994 ANALOG SPECIAL SUPPLEMENTS

JOIN THE GROWING LIST OF SUCCESSFUL ADVERTISERS IN 2 SPECIAL ANALOG SUPPLEMENTS FROM THE EDITORS OF ELECTRONIC DESIGN

Based on surveys taken after last year's analog supplement, reader polls showed a great deal of interest in analog specific topics. A whopping 98% of our readers surveyed favored the publishing of additional analog focused supplements! Readers strongly felt that these supplements should be published regularly (with some readers requesting quarterly releases).

Based on that information, the Editors of Electronic Design Magazine have decided to continue the coverage of analog applications by releasing two supplements yearly, one in June and one in November.

Join with many of our advertisers who found great success placing in last year's analog supplement. For some companies, reader response card inquiries pushed over 1600 per item- with numerous requests for reprints of the entire supplement!

The editors were impressed by the amount of mail received praising that analog supplement and requesting future supplements.

The analog supplements for this year will feature these basic editorial elements:

In-depth Applications - written by noted industry experts.

Application Briefs - covering a wide range in terms of topics.

Literature - A new literature section that presents the latest in current application handbooks available from manufacturers of analog chips.

Bob Pease - contributing a special column for this supplement.

PLUS:

DEMO'S - a compendium of floppy-disk based demonstrations of analog circuit design and analysis software packages.

ANALOG SUPPLEMENTS

ISSUE DATE JUNE 27, 1994
CLOSING DATE: MAY 17,1994
ISSUE DATE: NOVEMBER 7, 1994
CLOSING DATE: SEPTEMBER 27, 1994

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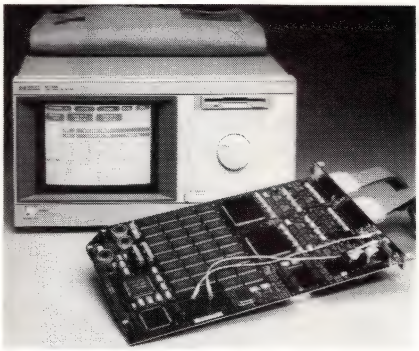
CALL US AT 201/ 393-6045, FOR FAX 201/393-6073

CARD ADDS 1-MSAMPLE TRACE MEMORY TO LOGIC ANALYZER

With a 1-Msample trace memory (2 Msamples in half-channel mode), the HP 16555A state and timing card for the HP 16500B logic-analysis system allows designers to trace widely separated cause-and-effect problems and perform deep-crash analysis. The 68-channel card features up to 500-MHz timing and 125-MHz state analysis.

All of the 16555A's channels can perform state or timing analysis, so the user does not have to reprobe the system to change analysis modes. Users can connect up to five cards to create a 340-channel analyzer with triggering across all channels. With an HP 16501A expander mainframe, up to 10 cards can be used in a 680-channel system.

A key feature of the new card is the ability to trigger other cards sets in the 16500B mainframe. In this way, multiple processors can be analyzed simultaneously. The card interleaves listings and waveforms between analysis modules for maximum readability and time correlation. A library of trigger macros make triggering convenient. A hardware-accelerated display and search mode also speeds analysis.



A number of microprocessor-specific preprocessor interface modules ease connections to most popular microprocessors. The preprocessors supply a low-profile mechanical connection and inverse assembler, greatly reducing start-up times.

The HP 16555A timing and state card costs $13,500, and the HP 16500B mainframe costs $8800. Delivery is in six weeks for the card, two weeks for the mainframe.

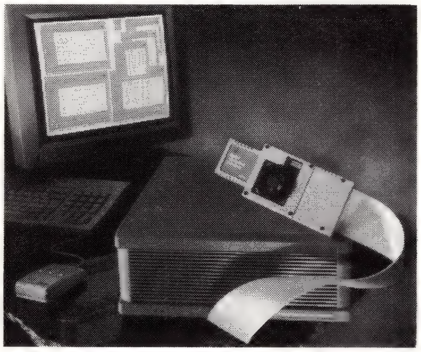
Hewlett-Packard Co., *Direct Marketing Org., P. O. Box 58059, MS51L-SJ, Santa Clara, CA 95051-8059; (800) 452-4844 ext 8167.* **CIRCLE 612**

■ *JOHN NOVELLINO*

EMULATOR SUPPORTS MULTIPLE-68040 DESIGNS AT UP TO 40 MHZ

As a microprocessor-specific emulator, the CodeICE 040 targets the embedded systems developer's need for faster, lower-cost, and more focused development tools. The 40-MHz emulator supports designs using 68040/68360 processors or multiple 68040 devices.

The full-featured emulator includes a complex-trace and event system, with a trace memory (with time stamp) that captures 136 bits of information about each bus cycle to a depth of 32 kframes. A unique intelligent trace disassembler tracks the state of registers, and a correlated assembly-to-source trace display is shown in one window to clarify the relationship between the two levels of code.



An integrated source-level debugger supports either Windows on a PC or X-Windows on a Sun 4 workstation, and runs either standalone or as an integrated element of the MRI MasterWorks environment. The debugger is compatible with a number of popular compilers and supports both C and C++. Target hardware can be debugged through a fully isolated probe tip and dignostic scope loops.

The overlay memory of up to 4 Mbytes handles both burst and normal access with zero wait-states to 25 MHz. The system works with real-time operating system monitors and accommodates cache coherency and bus snooping for targets with multiple 68040s.

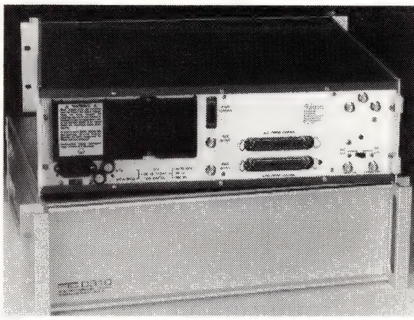
Until June 30, the CodeICE 040—including the 40-MHz emulator, 8-kframe trace memory, and PC debugger—will be available at an introductory price of $19,950. Other configurations are available. Delivery is in four weeks.

Applied Microsystems Corp., *P. O. Box 97002, Redmond, WA 98073-9702; (800) 426-3925 or (206) 882-2000.* **CIRCLE 613**

■ *JOHN NOVELLINO*

BROADBAND SYNTHESIZER FEATURES TWO CHANNELS

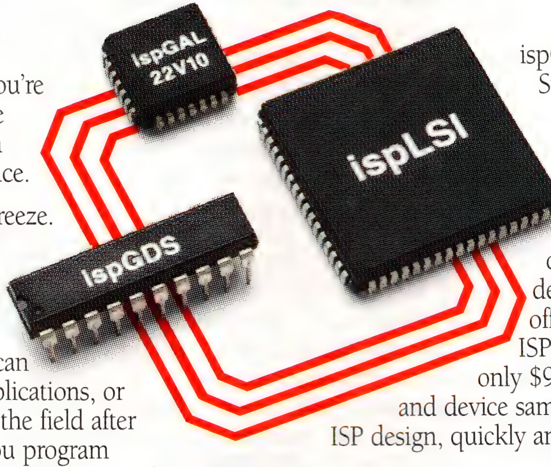
The PTS D310 broadband frequency synthesizer supplies two fully independent channels, covering 100 kHz to 310 MHz with 0.1 Hz resolution. The instrument's frequency switching speed is 20 μs or better. Phase noise at 310 MHz is –115 dBc/Hz at a 1-kHz offset, and spurious outputs are –70 dBc or better. The unit can output up to +13 dBm. Each channel is controlled through its own 50-pin parallel interface connector, compatible with those on previous PTS synthesizers. The PTS D310 costs $7700, with delivery within 60 days. A temperature-compensated crystal oscillator cost $260, and an oven-controlled crystal oscillator is $525. JN



Programmed Test Source Inc., 9 Beaver Brook Rd., P. O. Box 517, Littleton, MA 01460; (508) 486-3008. **CIRCLE 614**

Get Rid of Caveman Logic.

Get In-System Programmability!



If you're still designing with conventional PLDs and FPGAs, you're using Stone Age technology. Move up to a superior logic—In-System Programmability (ISP™) from Lattice.

With ISP, system design is a breeze. ISP lets you program and modify logic *after* the devices are soldered to your p.c. board—dramatically reducing your product development time. You can design one board for multiple applications, or even reconfigure your product in the field after it's been shipped. And ISP lets you program devices without a dedicated programmer, simplifying your manufacturing and eliminating bent device leads caused by hungry programmer sockets.

Lattice offers a complete family of ISP devices, from ispLSI™ High-Density PLDs, to the ispGAL22V10 and ispGDS™ programmable Generic Digital Switches. So you can use ISP devices across your board for any logic function. To make the development of your next design easy, we're offering a complete ISP development kit for only $99. All the design software, hardware and device samples you need to complete your first ISP design, quickly and easily.

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Go ahead, get rid of the caveman logic. For information on how to move up to ISP and obtain an ispStarter™ Kit, call **1-800-327-8425** today and ask for information packet 318.

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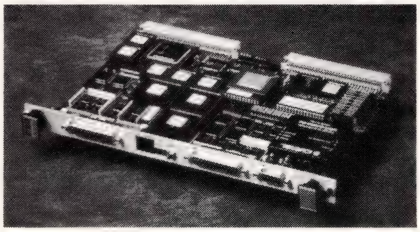
CONNECT TAPE RECORDER TO VME SYSTEM

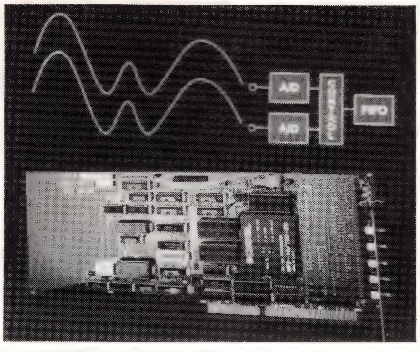
It's easy to connect a Sony DIR-1000 tape-recorder to a VMEbus or VME64 system using the DIR-930 6U interface board. Applications for this type of setup include signal and image processing, telemetry, data acquisition, simulation, and visualization. The board, which supports the recorder's maximum transfer rate, 32 Mbytes/s, is an intelligent buffered interface that's built with a 33-MHz 68030 CPU. It can operate as a master or slave and comes with a mezzanine slot that can hold an Ethernet or DMA-VSB module. Automatic fill generation and removal enable the data-source rate to match the recorder. Comprehensive software implements a high-level command interface. The DIR-930 interface board is available now for $18,000. RN



Myriad Logic Inc., 1109 Spring St., Silver Spring, MD 20910; (301) 588-0604. **CIRCLE 615**

BOARD SIMULTANEOUSLY SAMPLES TWO ADCS

Offering a high system speed, the PC-414 multi-channel analog input board fits IBM-compatible PCs. Full-power input bandwidth up to 2.5 MHz is available and can be sampled at 5 MHz. The analog section of the board fits onto a plug-in module. As a result, different sample-and-hold and analog-to-digital-converter speeds and resolutions can be employed.



Two channels, each with 12-bit analog-to-digital converter resolution, can be sampled simultaneously at 2 MHz. The local FIFO memory prevents a data loss by moving samples in fast block bursts while the collection continues concurrently. The sample clock can employ a programmable on-board timebase or an external clock. Data can be transferred to the host PC bus or to a 10-MHz nonbus parallel port that connects directly to the various array processors. Interrupts are supported from several sources, as well as DMA or fast I/O block transfers. The board comes in different variations. Prices start at $1995. Executable versions of the setup and configuration software is available. RN

Datel Inc., 11 Cabot Blvd., Mansfield, MA 02048; (508) 339-3000. **CIRCLE 616**

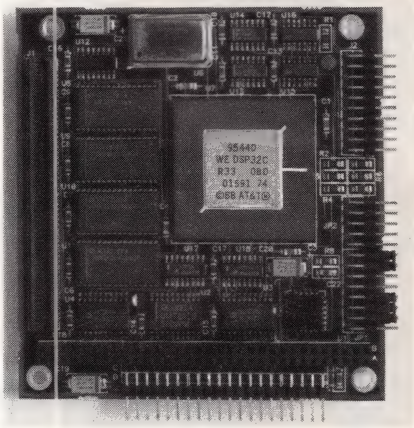
ANALOG I/O BOARD HANDLES 16 CHANNELS

Designed to simplify the interface between digital-signal processors and analog signals, this 16-channel analog I/O card uses two gate arrays to handle the analog conversion process. This reduces the DSP overhead. Also included is an interrupt line that triggers a DSP interrupt at a user-defined sample rate ranging from 7 to 48 kHz. The card's modular design permits 4, 8, 12, or 16 I/O channels. Each input is a 16-bit, 64-times over-sampling analog-to-digital converter with an eighth-order anti-aliasing filter. In addition, each output is a 16-bit digital-to-analog converter with an eighth-order reconstruction filter. All I/Os are differential, with the outputs capable of driving low-impedance loads directly. Available now, the analog I/O card sells for $5195 in single quantities with 16 I/O channels. RN

SimPhonics Inc., 6802 Citicorp Dr., Suite 200, Tampa, FL 33619; (813) 623-9917. **CIRCLE 617**

DSP BOARD FITS PC/104 FORM FACTOR

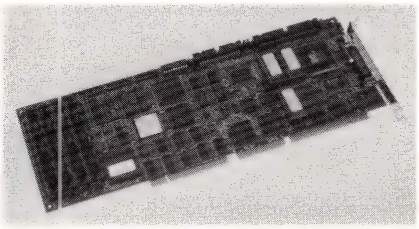
Because the PC5-DO floating-point DSP boards fit the PC/104 form factor, they can be stacked to increase performance. Based on AT&T's 50-MHz DSP32C, the board holds 512 kbytes of zero-wait-state SRAM and is built with a 25-Mbit/s serial I/O port with independent DMA. The module also supplies a separate 32-bit, 100-Mbyte/s mezzanine connector. A carrier card (base board) with the PC/104 interface is also available. The carrier card supports various audio daughter board options, and communicates through its serial I/O port. The carrier card sells for $195, while the PC5-DO costs $1395. Both are available now. RN



Communication, Automation and Control Inc., 1642 Union Blvd., Suite 200, Allentown, PA 18103; (215) 776-6669. **CIRCLE 618**

SCSI CACHE CONTROLLER FITS VL-BUS

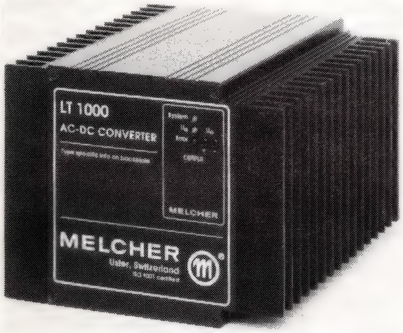
Up to 64 Mbytes of SIMM memory fit on the 32-bit VL-Bus-to-SCSI cache controller. The CSA-6300 employs a proprietary caching technique to speed up the SCSI host caching algorithms in complex graphics applications. The advanced tag-RAM architecture off-loads the host microprocessor, resulting in maximum efficiency and reduced CPU overhead. The board supports DOS, Windows, Windows NT, OS/2, Netware, and Unix. A software utility comes bundled with the CSA-6300 to simplify installation. The CSA-6300 is available now for $599. RN



CMD Technology Inc., 1 Vanderbilt, Irvine, CA 92718; (800) 426-3832 or (714) 454-0800. **CIRCLE 619**

EFFICIENT SUPPLIES HAVE UNIVERSAL INPUT

Providing 400 W at a regulated 54 V dc, the LT1700 family of ac/dc converters features transient suppression, filtering, control, and shock and vibration immunity. The fully enclosed 4-by-5-by-7-in. supply also offers power-factor correction, efficiency of up to 93%, and no inrush current. Supplies can be configured in parallel and in redundancy, with up to three units in one 5.25-in. rack. A negative temperature coefficient allows for safe battery charging without danger of thermal runaway because the trickle-charge voltage drops as ambient temperatures rise. Pricing starts at $1036 in singles. Delivery is in 6 weeks. DM



Melcher Inc., 187 Billerica Rd., Chelmsford, MA 01824; (800) 828-9712. **CIRCLE 620**

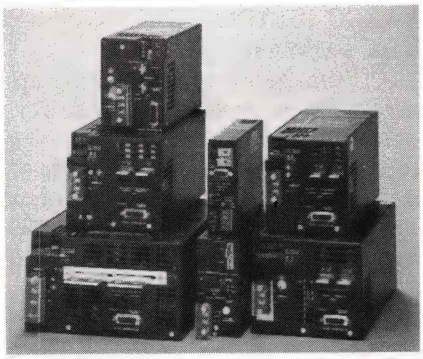
6-IN-1 IGBT MODULES BOAST HIGH RATINGS

The highest available power ratings for 6-in-1 IGBT modules is boasted by the CM150TF-12H, CM75TF-24H, and CM100TF-24H H-Series IGBT modules. The units, which contain third-generation chips, offer continuous collector-current ratings of 75 and 100 A and a V_{CES} of 1200 V, or an I_C of 150 A and a V_{CES} of 600 V. The chips are designed to provide the lowest possible total power loss when considering the sum of static and dynamic operation power losses. All modules also contain an ultrafast soft-recovery diode, which contributes significantly to lower turn-on losses. Typical pricing is $262.15 for the CM150TF-12H (600 V/150 A) and $359.89 for the CM100TF-24H (1200 V/100 A), both in lots of 10. Delivery is from stock to 6 weeks. DM

Powerex, 200 Hillis St., Youngwood, PA 15697; (800) 451-1415. **CIRCLE 621**

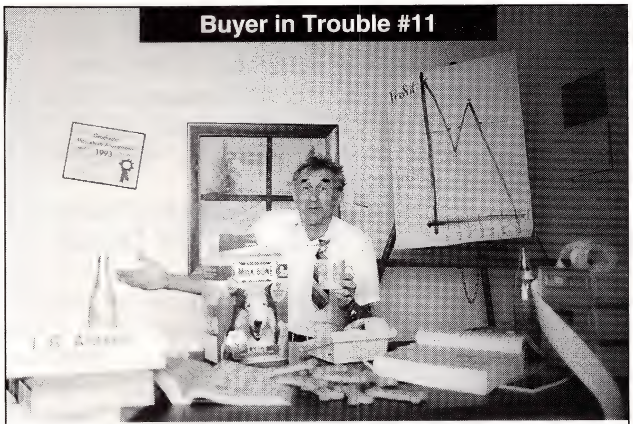
RUGGED SUPPLIES MEET MANY STANDARDS

Four major threats are posed to a power supply's reliability by the North American industrial environment, and the SE Series of power supplies is poised to fend them off. The threats include ac-line transients, elevated temperatures, shock, and vibration. Heavy machinery can cause the ac-line voltage to sag for a half cycle and to surge as high as 170 V ac for up to 1 s. The SE Series supplies' input section is designed to operate normally under such conditions and meets the input-transient specs of IEC-801-2-3-4 and IEEE-587 Category A3. Their thermal design keeps all internal components well within their published stress ratings. Compliance to MIL-STD-810E shock and vibration specs maintains performance under the harshest conditions. Twenty-two models are available from 50 to 1500 W. Pricing starts at $234. DM



Lambda Electronics Inc., 515 Broad Hollow Rd., Melville, NY 11747; (516) 694-4200. **CIRCLE 622**

Buyer in Trouble #11



Profit Margin of Error

"How was I to know that paying a little too much for pc power transformers would make the bottom line hit the bottom line? Money ain't everything. Right?
I'm dead meat.

I *really* shoulda called Prem.

You oughta call Prem!"

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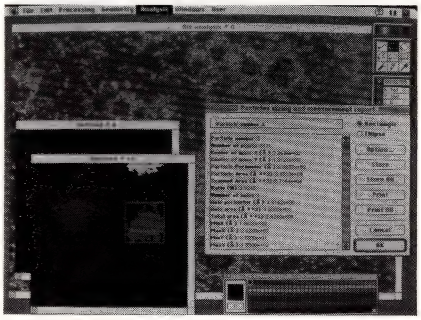
Phone: 815-385-2700. FAX: 815-385-8578.

READER SERVICE 116

IMAGE PROCESSING FOR POWER MAC

The Ultimage scientific imaging application now comes in a native version for the Power Macintosh. The software has the Macintosh tools of magic wand, freehand and contour detection, along with a library of 400 image acquisition, enhancement, and display functions that handle 1-, 8-, 16-, 24-, and 32-bit images in various file formats. Algorithms handle more than 60 shape and density measurements for each object recognized in an image. The software outputs statistical reports and charts and can export image-processing results to spreadsheets or other Macintosh applications for analysis. SVT



East Coast: Engineering Technology Center, 240 Oral School Rd., Mystic, CT 06355-1208; (203) 572-9600; West Coast: GTFS, 255 Bennett Valley Rd., Suite 100C, Santa Rosa, CA 95404; (207) 579-1733. **CIRCLE 623**

SOFTWARE FOR HELP AUTHORING

RoboHelp 2.6, a help-authoring system for Windows and Windows NT, turns Word 6.0 for Windows into a help-authoring system that easily produces Windows Help files. It automatically converts existing text into a help system, or a help system into user documentation. It can import existing Word files and convert headings to topics, and index entries converted to search keywords. RobotHelp also imports existing Help project source code. The software enables users to create topics and jumps by adding a graphical tool palette to Word 6.0 for Windows. Users can access features of the windows Help engine, such as macros, secondary windows, and multiple hotspot graphics. Error Wizard detects potential errors before compilation and explains how to resolve them. List price is $499; upgrades from version 1.0 are $229; $29 from version 2. SVT

Blue Sky Software Corp., 7486 La Jolla Blvd., Suite 3, La Jolla, CA 92037; (619) 459-6365. **CIRCLE 624**

SOFTWARE TOOL DOES GRAPHIC DATA DEBUGGING

Supplying non-graphic, logic-based debugging controls to be embedded in an user program under development, the Data Debugging Toolset now runs on Sun workstations and Motorola 167 and CSPI i860 Supercards. DDT is an efficient, low-cost solution to debugging with complex data-manipulation software. Filling the gap between standard source-code debuggers and generic graphic toolsets, the DDT routines generate remote X11 graphic displays, with which the user can view program data results on a Sparc Unix host, control debugging flow, and analyze massive data arrays in a graphical form. Controls allow the user to step through a program or view the results after computations without intervention. The DDT tool goes for $499 per library. SVT

CST Images, 5055 Viewridge Ave., San Diego, CA 92123; (619) 277-7833; fax (619) 576-0859. **CIRCLE 625**

PROGRAM TURNS PCS INTO LOW-COST IMAGE STATIONS

XoftWare/32 for Windows with XIE Option turns personal computers into low-cost image display stations for Unix-based applications. The software is said to be the first commercial product to implement the X Image Extension (XIEv5.0), the imaging standard for Unix. With this 32-bit X-server software, users can concurrently access and display Windows and networked-based Unix applications on the same screen. The software also has many features and utilities to simplify interaction and information exchange between PC and Unix systems. A Windows-based file-transfer utility, a local printer utility, and the ability to use local and Unix windows managers are included. List price is $595. SVT

AGE Logic Inc., 9985 Pacific Heights Blvd., San Diego, CA 92121; (619) 455-8600; fax (619) 597-6030. **CIRCLE 626**

REAL-TIME IMAGING OS EASES DESIGN

Building onto the real-time, multitasking facilities in real-time operating systems like VRTX, pSOS, and VxWorks, PeerlessPage is a real-time multitasking OS for printing and imaging applications. The OS's multitasking facilities simplify laser-printer controller design by enabling controllers to manage multiple printer control activities concurrently. These facilities also simplify the design of multifunction products, enabling a single controller to simultaneously manage diverse functions, such as printing, scanning, copying, and faxing. It takes advantage of the memory reduction technology (MRT) acceleration of printer coprocessors like Intel's i82961KD and Motorola's integrated MC68322. The OS also supports performance and image enhancement ICs, like XLI's Super LGA ICs and DP-Tek's TrueRes ICs.

Besides core services like scheduling, interrupt handling, I/O functions, and memory management, PeerlessPage supplies such specialized services for printing and imaging controllers as PDL interpretation, host/printer communication, printer engine I/O, front-panel control, and high-speed graphics rendering. The OS also incorporates font management and can manage multiple I/O streams simultaneously.

To increase code portability, reusability, and extensibility, as well as to shrink time to market, PeerlessPage relies on a scalable, modular, layered software architecture. By isolating application programs from the underling hardware, the OS enables OEMs to develop applications that can be implemented on any PeerlessPage controller with few if any source-code changes.

The OS's kernel implements core real-time facilities—task scheduling and management and timer and interrupt services. Call for prices.

Peerless Systems Corp., *2381 Rosecrans Ave., Suite 400, El Segundo, CA 90245; (310) 536-0908; fax -0058.* **CIRCLE 627**

■ *SHERRIE VAN TYLE*

MIXER SIMPLIFIES WIRELESS APPLICATIONS

Operating from dc to 2 GHz, the PMB 2206 quadrature phase modulator and mixer provides cost and space savings for a variety of wireless applications, including cellular phones (IS 54/55, GSM, and PCS), PDAs, and PCS. Available in a 20-pin plastic dual small-outline surface-mount package (PDSO), the chip converts baseband signals into an RF carrier frequency in an on-chip transmitter. With an operating current of 40 ma and 0.15 micro amps at standby, the PMB is well suited to low-power applications. Available now in samples, full production is anticipated for third quarter of 1994. Quantity pricing will be as low as $5.25. LG

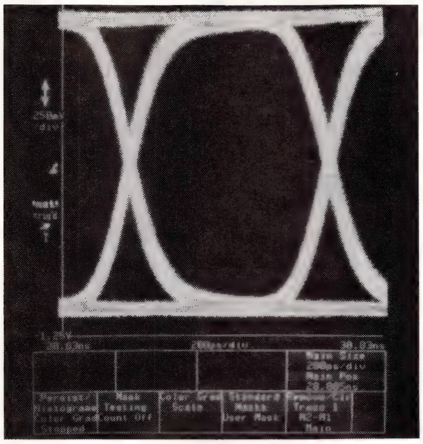
Siemens Components, Integrated Circuit Division, 10950 North Tantau Ave., Cupertino, CA 95014; (800) 777-4363. **CIRCLE 628**

TRANSCEIVER SUPPORTS 155 MBIT/S ON CAT-5 WIRE

The ML6672 transceiver chip utilizes adaptive signal-conditioning technology to support data transmission on inexpensive category-5 twisted-pair wire. Operating at up to 155 bits/s over distances of up to 100 meters, the chip transmits data using an ECL 100K-compatible NRZI signal. The adaptive tuning system in the ML6672 determines the wire length by tuning the receiver to match the characteristics of the wire. The transceiver is packaged in a 32-pin PLCC and is priced at $20 in lots of 1000. LG

Micro Linear Co., 2092 Concourse Dr., San Jose, CA 95131; (408) 433-5200. **CIRCLE 629**

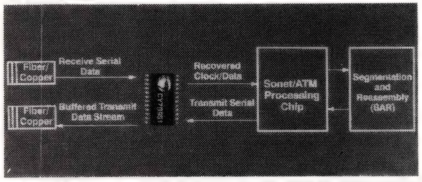
CROSSPOINT SWITCH IC HANDLES 800 MBIT/S



Aimed at extremely high-speed network applications, the TQ8032 digital crosspoint switch provides designers with a building block for hubs, routers, and any switching device for digital audio, video, or data. The 32-by-32 point switch offers a bandwidth of 800 Mbits/s for each channel and boasts extremely low distortion characteristics. With a maximum skew of less than 280 ps and jitter below 100 ps, the chip's performance margin permits the use of multiple switches for creating larger matrices. The TQ8032 digital crosspoint switch is available immediately, as is the companion TQ8016, which offers a 16-by-16 switch matrix with a 1.6-Gbit/s bandwidth per channel. Prices are $500 for lots of 25, and $406 in lots of 1000. LG

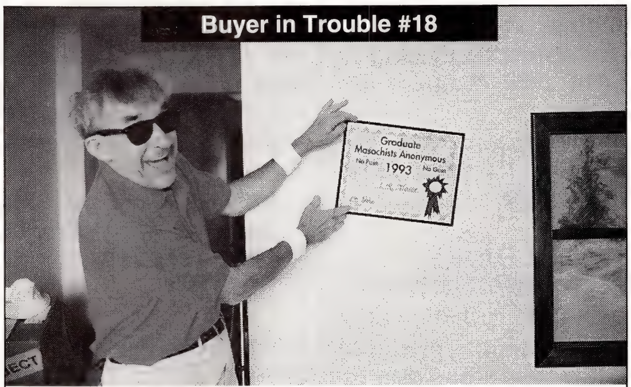
TriQuint Semiconductor, 3625A S.W. Murray Blvd., Beaverton, OR 97005 (503) 644-3535; Dave Drummond, ext. 225. **CIRCLE 630**

FAST TRANSCEIVER OPTIMIZED FOR SONET



The CY7B951 SONET/SDH Serial Transceiver, SST, is a high-speed data-communications product that interfaces seamlessly with leading ATM controllers. It offers clock and data recovery from both 155.52- and 51.84-MHz serial data streams, providing a low-jitter, physical layer interface for ATM, SONET, and SDH applications. It can recover clock and data from both NRZ and NRZI data streams. It operates on 50 mA of operating current, 50% less than competitive products. The SST comes in a 24-pin SOIC package. In lots of 100, it costs $45 each. CA

Cypress Semiconductor, 3901 N. First St., San Jose, CA 95134-1599; (408) 943-2817. **CIRCLE 631**



"Real Men Don't Mind Rejects!

But my boss disagrees. He wanted me to buy 100% final tested Prem transformers instead of the statistically sampled jobs I got. Now he's having my photo laminated to every box of rejects. I'm dead meat.

I *really* shoulda called Prem.

You oughta call Prem!"

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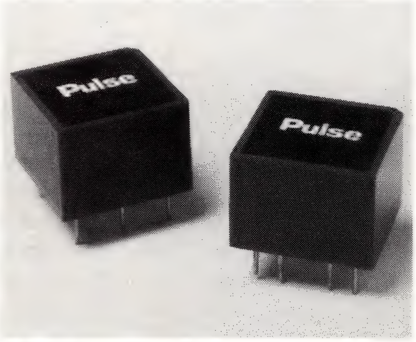
READER SERVICE 117

ISDN TRANSFORMER MEETS ISOLATION SPECS

A series of transformers for ISDN-BRi S-interface applications meets the international standards on safety and 3000-V isolation. The units fully comply with requirements for reinforced insulation according to IEC 950 and EN41003/EN60950. This adherence to increasingly enforced regulatory documents comes in a package that's just 0.5 in. tall maximum. The devices also provide a dc-bias current capability up to 5 mA. Applications for these upgraded transformers include interface boards for desktop multimedia, video conferencing, and integrated voice-data capabilities. Pricing is $3.50 in lots of 1000. Samples are available now. DM



Pulse Engineering Inc., P.O. Box 12235, San Diego, CA 92112; (619) 674-8100. CIRCLE 632

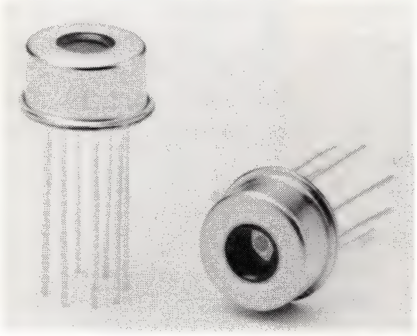
VISIBLE LASER DIODE HAS BRIGHT 5-MW OUTPUT

A bright 5-mW output that's easily visible even in daylight is produced by the HL6312G solid-state laser diode. Because the device's 0.63-μm light is the same wavelength as that produced by helium neon gas lasers, the diode can improve the reliability, lower the cost, simplify the design, and reduce the size of visible-light products such as bar-code readers, laser pointers, and leveling systems. The unit is built with a multi-quantum well structure that's more efficient than traditional double-heterojunction constructions. The laser's 5-mW minimum optical output power is achieved with an operating voltage of 2.7 V and an operating current of 65 mA typical, making it suitable for battery-powered applications. It comes in a compact, rugged G-type hermetic metal can. Pricing is $70 in lots of 1000. Samples are available now. DM

Hitachi America Ltd., Semiconductor and IC Div., 2000 Sierra Point Pkwy., Brisbane, CA 94005-1819; (800) 285-1601, ext. 82. CIRCLE 633

AVALANCHE PHOTODIODE IS SECTORED IN FOUR

The model S4402 is a silicon avalanche photodiode with a 1-mm active area that's divided into four equal sections. It's suitable for applications such as low-light detection and laser-beam alignment. Spectral response is from 400 to 1000 nm and peak-sensitivity wavelength is 800 nm. Quantum efficiency is 75% at peak and dark current is typically 0.8 nA. The diode operates from –20 to +60°C. Delivery is from stock. Call for pricing. DM



Hamamatsu Corp., 360 Foothill Rd., Box 6910, Bridgewater, NJ 08807-0910; (908) 231-0960. CIRCLE 634

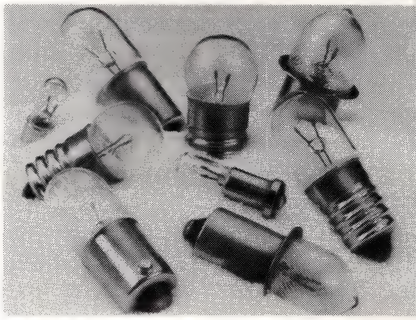
LOW-NOISE FANS BOOST EFFICIENCY

Available in three frame sizes, the KL Series axial fans offer a performance level that's up to 15% higher than previous products. The fans' blade design provides better airflow at a lower speed, resulting in less noise and greater energy efficiency. In addition, their one-piece molded bearing-liner housing makes them lighter than others currently available. The 1606 KL measures 1.6 by 0.6 in., the 3110 KL measures 3.1 by 1 in., and the 3610 measures 3.6 by 1 in. Pricing in lots of 1000 is $8.50, $9, and $10, respectively. Call for delivery information. DM

NMB Technologies Inc., 9730 Independence Ave., Chatsworth, CA 91311; (800) 662-8321. CIRCLE 635

GAS-FILLED LAMPS RANGE FROM 2 TO 28 V

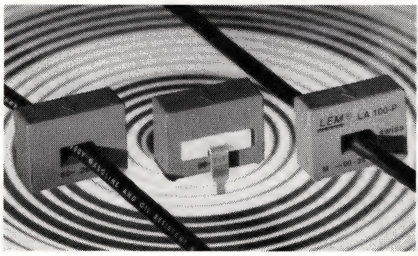
A line of krypton-, zenon-, and argon-filled lamps is available with operating voltages that range from 2 to 28 V. The subminiature and miniature lamps are offered with a variety of base styles including flange base, screw base, and bayonet. They're also offered with or without lenses. Call for pricing and delivery. DM



Wamco Inc., 11555-A Coley River Circle, Fountain Valley, CA 92708; (714) 545-5560. CIRCLE 636

CURRENT TRANSDUCERS MOUNT ON BOARDS

A built-in, bus-bar-type primary conductor is featured in the LA 55-P and LA 100-P Series of pc-mountable current transducers. These Hall-effect devices offer non-contact measurement of currents up to 50 A (55-P) and 100 A (100-P) nominal. They're completely self-contained and require no extra circuitry to sense or signal. The current being sampled can be run on the pc-board trace that connects to the through-hole bus bar built into the module. The 100-A version is claimed as the world's smallest full-performance transducer featuring thermal-drift stability and superior response time, linearity, and frequency response. Typical pricing for the 100-A unit is $19.70 without the bus bar and $21.40 with it, both in lots of 500. DM



LEM USA, 6643 West Mill Rd., Milwaukee, WI 53218; (414) 353-0711. CIRCLE 637

Go Configure

Spectrum's QPC40 supports up to four C40 modules, allowing you to configure a variety of processor networks.

The MDC40T dual C40 module delivers 100 MFLOPs of power on a single-width DSP module.

PC C40

Develop dual, quad, or even octal parallel processing DSP systems—all with powerful TIM-40™ modules from Spectrum. Where you'll find the industry's broadest line of DSP embedded products and development software for the PC.

Which means you'll get quick time-to-market and low-cost OEM C40 boards for the PC platform.

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Putting DSP to Work

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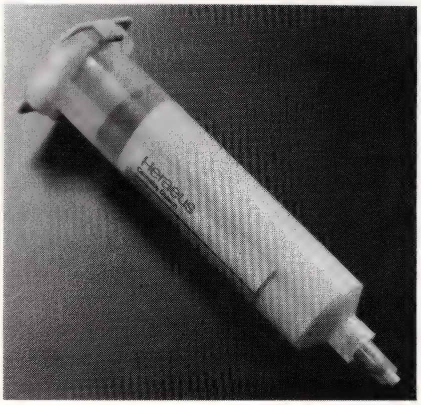
READER SERVICE 198

YELLOW SMT ADHESIVE SHOWS ON OPTIC SCANS

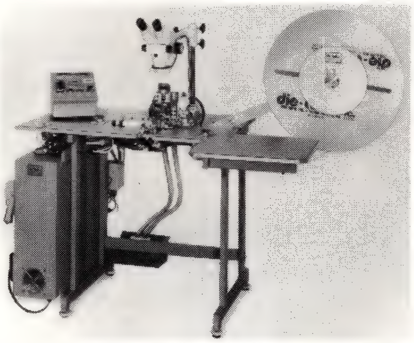
A line of thermosetting polymer SMT adhesives is yellow in color for compatibility with laser optics used in dot checking. The PD860002, PD911, and PD922 adhesives are single-component, solvent-free polymers developed for high-speed applications with very small devices, telecommunications and other high-reliability applications, and surface mounting of components onto pc boards, respectively. Their yellow color suits them well for applications where the machine optics that measure dot height cannot pick up standard red adhesives. DM



Heraeus, Cermalloy Div., P.O. Box 306, West Conshohocken, PA 19428-9306; (610) 825-6050. CIRCLE 638

LEAD-ATTACH MACHINE INSERTS QFP LEADFRAMES

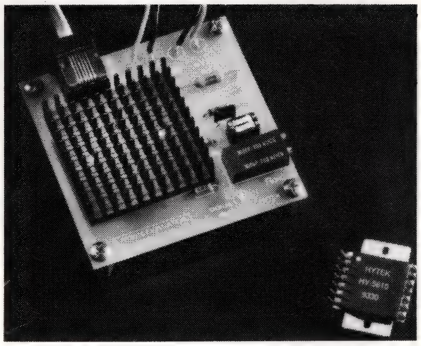
Low-cost, precise insertion of fine-pitch clip leadframes into surface-mount ceramic quad packages is performed by the Model 2991-4 semiautomatic lead-attach machine. Users simply program the required number of leads per package side into the machine. The lead strip is automatically indexed into correct insertion position, trimmed to size, and inserted on one side of the substrate. The machine rotates the substrate until all sides are completed. Microprocessor control ensures accurate leadframe indexing and cutoff position. Changeover tooling provides easy conversion to different lead pitches, accommodating packages from 20 through 40 mm^2. Pricing for the machine is $57,500. Delivery is in 10 to 12 weeks. DM



Die-Tech Inc., 295 Sipe Rd., York Haven, PA 17370; (717) 938-6771. CIRCLE 639

DEVICE HEATS/COOLS COMPONENTS AS NEEDED

A subminiature thermoelectric heater/cooler controller precisely controls the temperature of sensitive electronic components. The HY-5610 controller is designed for fixed-temperature applications where front-panel controls and digital readouts are not required. Uses include controlling the temperature of laser diodes, photo-optical detectors, quartz crystals, sensors, and low-noise solid-state amplifiers. The controller teams with a thermistor bridge to precisely measure and regulate the temperature of a device affixed to a thermoelectric cooler. It provides proportional control of temperatures above and below ambient. Call for pricing and delivery. DM



Hytek Microsystems Inc., 400 Hot Springs Rd., Carson City, NV 89706; Lisa Hersey, (702) 883-0820. CIRCLE 640

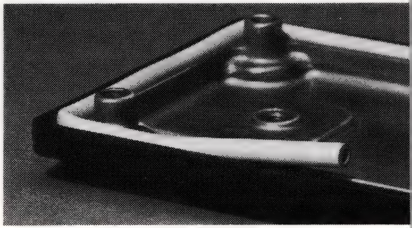
ENHANCED FILMS IMPROVE PHOTOTOOLS

An enhanced Ultraline film for production of high-quality phototools combines the advanced features of the company's Ultraline film UP 7 photoplotting/projection products with a number of enhancements. These include improved image quality for finer line edges, enhanced scratch and abrasion resistance, preprocess anti-static characteristics and higher density levels (typically to 5.0). The films are coated on an optical-quality, 7-mil Estar polyester base with excellent dimensional stability. Call for pricing. DM

Eastman Kodak Co., 343 State St., Rochester, NY 14650-0519; (800 242-2424. CIRCLE 641

EMI GASKETS OFFER IMPROVED QUALITIES

The physical properties of Cho-Seal conductive elastomer EMI-shielding gaskets have been improved. Used in cellular phones and other small electronic packages, the gasket material consists of a silver-filled silicone elastomer applied over a non-conductive silicone tube. The Cho-Seal 3000 gaskets provide 60 dB of shielding effectiveness from 200 MHz to 10 GHz and can be stretched 150% without loss of coating abrasion or electrical conductivity. Six diameters are available from 0.040 in. (1.02 mm) to 0.125 in. (3.18 mm). Call for pricing and delivery. DM



Chomerics Inc., 77 Dragon Ct., Woburn, MA 01888; (617) 935-4850. CIRCLE 642

POLY RESIN MAKES FOR EASIER PROCESSING

Improved surface appearance, paintability, and dimensional stability are combined with lower processing temperatures and pressures in the Calibre 5101-15 polycarbonate resin. The high-flow material is 10% glass-filled for higher strength in walls as thin as 2.5 mm. It offers high impact resistance, high heat resistance, and excellent dimensional stability. Numerous applications exist in the electronics, appliance, and medical markets. Call for pricing. DM

Dow Plastics, P.O. Box 1206, Midland, MI 48641-1206; (800) 441-4369. CIRCLE 643

STARTING AT THE TOP.

Together, TSSI and SEE Technologies have risen to new heights.

TSSI – the leader in test program development, timing specification, and VHDL design management – and SEE Technologies – a rising star in graphic design systems for HDL – have merged to become Summit Design, Inc. The one electronic systems design automation (ESDA) and test development company that looks at top-down design from a higher point of view. The only one that can help you do the same.

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Tools for the top. As Summit, we deliver the most comprehensive ESDA solutions. Powerful graphics- and text-based HDL development tools. The world's only hierarchical top-down timing specification system. And expanded test development solutions, including industry-standard links from design to production test.

Heightened your interest? We hope so. Why not call us at 1-800-642-9281? See for yourself how Summit can help you raise design productivity to new heights.

Summit Design, Inc.

9305 S.W. Gemini Drive, Beaverton, OR 97005-7158

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READER SERVICE 200

PROCESS- AND DATA-MANAGEMENT TOOL AUTOMATES FPGA DESIGN FLOW

A process- and data-management tool from Viewlogic called ViewFPGA provides automation that moves engineers toward "push-button design" of field-programmable gate arrays (FPGAs). In addition to the management capabilities, the system offers intelligent decision making, automated integration to system-level design, and tight integration with FPGA layout.

ViewFPGA is an intelligent command center that controls and expedites the FPGA design process. It actually consists of more than 50 tools and utilities that transparently interact with users.

The decision-making feature helps engineers with device selection, tool invocation, and file creation and management. It also manages each step in the design process, including integration with vendor-specific place and route. For example, users don't need to know the specific commands to go from a schematic to simulation because ViewFPGA handles that automatically. The software ensures that the design process undergoes the proper sequence of events.

Users enter designs with any combination of schematic, ABEL, Jedec, or VHDL inputs. The system's synthesis technology lets users create designs without regard to how it will be implemented. Then, ViewFPGA's device selector helps choose target devices by manufacturer, speed, cost, power, and pin count.

Viewlogic is offering two design solutions built around ViewFPGA. Programmable Architect is a design-entry and verification environment that can be combined with any vendor's place-and-route tools. The second solution, Programmable Expert, adds integrated silicon-vendor-specific place-and-route tools and partitioning capability for Actel, Altera, or Xilinx devices.

All the tools run on Unix workstations and on personal computers under Windows. The Windows versions of ViewFPGA, Programmable Architect, and Programmable Expert cost $5750, $21,000, and $25,000, respectively. The Unix versions of those same products go for $8200, $25,000, and $30,000.

***Viewlogic Systems Inc.,** 293 Boston Post Rd. West, Marlboro, MA 01752; (508) 480-0881.* **CIRCLE 644**

■ *LISA MALINIAK*

FPGA TOOL SUITE OFFERS UPGRADE PATH

The FPGA Station suite of tools from Mentor Graphics provides upgrade paths to full ASIC and board design to protect users' initial investment as their needs evolve over time. FPGA Station supports all types of programmable logic, including FPGAs, complex PLDs, and simple PLDs. It's a vendor-independent environment that can be augmented to complete the design flow all the way to the FPGA programming file or the PLD Jedec file. The lowest-cost system accepts schematic-based entry, while the pricier Top Down FPGA Station version handles mixed-level VHDL and schematic descriptions. The top-down product also provides VHDL simulation, gate-level simulation, language-based synthesis, and device-specific optimization. Both products support more than 5200 programmable devices. Pricing for the FPGA Station tool suites start at $31,000. The systems currently run on HP and Sun workstations. LM

Mentor Graphics Corp., 8005 S.W. Boeckman Rd., Wilsonville, OR 97070-7777; (503) 685-7000. **CIRCLE 645**

PCB CAD SYSTEM HAS 32-BIT ARCHITECTURE

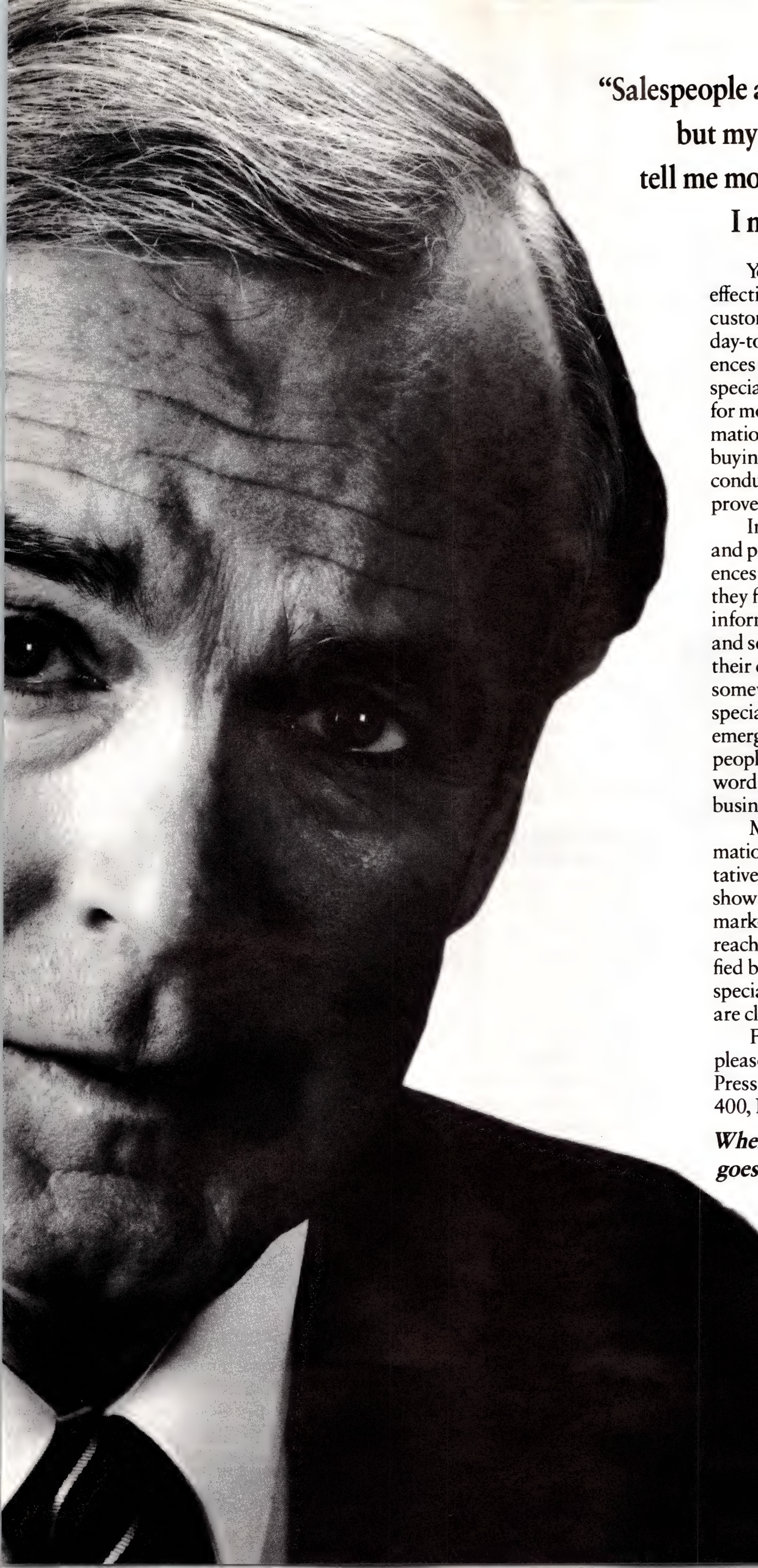
CADint PCB is a pc-board design environment built with a 32-bit architecture. The system supports virtual memory, uses an intelligent hierarchical database, and presents users with a window-based graphical interface offering programmable accelerator keys and icons. CADint PCB consists of a library manager, graphical symbol editor, logical- and physical-parts manager, schematic editor, bill-of-materials generator, pc-board layout editor, CAM station, mixed-mode simulator, and autoplacer and router. Database resolution is 0.01 μm, with support of 0.1° component rotation. The pc-board layout handles almost unlimited board size with 18 copper layers. In addition, designs can have an unlimited number of trace widths, pad-hole sizes, and via sizes and shapes. Surface-mounted components and analog design are fully supported. Call the company for pricing and additional product information. LM

CADint USA, 599 N. Mathilda Ave., Suite 5, Sunnyvale, CA 94086; (800) 553-1177. **CIRCLE 646**

SOFTWARE OPTIMIZES BOARD MANUFACTURING

Mitron will now sell Digital Equipment's internally-developed factory-scheduling software. Digital has used the Factory Scheduler at their pc-board assembly facilities to improve productivity by organizing circuit boards into compatible groups, which reduces the time spent on machine setup. Under the terms of the agreement, the Factory Scheduler software has been integrated into Mitron's CBPlan suite of planning and optimization software. Factory Scheduler helps efficiently load a circuit-board assembly plant in which a variety of printed-circuit assemblies must be produced simultaneously. To start, CBPlan analyzes a manufacturing situation to form groups of products that can be built using one setup. Then, Factory Scheduler assigns groups to certain production lines so that they are evenly loaded, and machine and component setup cycles are minimized. Factory Scheduler's output accounts for constraints such as time, material availability, and machine capabilities. The output can then be fed to other Mitron tools that handle machine setup for assembly and test, perform quality-management functions, and produce documentation. Factory Scheduler for Windows is shipping now. Pricing is set at $24,950. LM

Mitron Corp., 15256 N.W. Greenbrier Pkwy., Beaverton, OR 97006; (503) 690-8350. **CIRCLE 647**



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Your salespeople can be effective when they get to see a customer or prospect. But, on a day-to-day basis, the buying influences you need to reach turn to specialized industry publications for more of the important information that helps them make buying decisions. A recent study, conducted by the Forsyth Group, proves it.

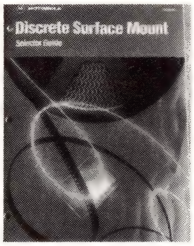
In the study, 9,823 business and professional buying influences were asked what sources they find most useful in providing information about the products and services they purchase for their companies. The results were somewhat surprising. Overall, specialized business publications emerged as the source business people turn to first. In other words, trade magazines are where business goes shopping.

Many other sources of information, including sales representatives, direct mail and trade shows, have their place in the total marketing mix. But if you want to reach the highest number of qualified buyers at the lowest cost, specialized business publications are clearly the best choice.

For a free copy of the study, please write to American Business Press, 675 Third Avenue, Suite 400, New York, NY 10017.

Where business goes shopping. **ABP**

DISCRETE SMT GUIDE HELPS WITH SELECTION



A revised Discrete Surface Mount Selector Guide (SG370/D) from Motorola Inc., Phoenix, Ariz., offers technical specifications on a wide variety of discrete semiconductors. These include many devices from Motorola's repertoire of reliability-proven semiconductor processes and geometries that are available in surface-mount packages. The selector guide is free. DM **CIRCLE 948**

HEAT-SHRINK PRODUCTS DESCRIBED IN CATALOG

The complete line of Pan-Shrink heat-shrink and abrasion-protection products is detailed in a 48-page, full-color catalog, No. SA101N48A from Panduit Corp., Tinley Park, Ill. The comprehensive reference contains full specifications, application information, and an easy-to-use product-selector guide. The products are designed to easily and economically insulate, protect, harness, and identify electronic and electrical components in a wide variety of applications. DM **CIRCLE 949**

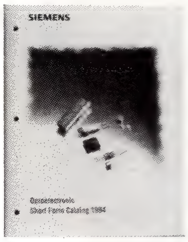
DISK HELPS CREATE DATA-ACQUISITION SYSTEM

The DAQ Designer interactive data-acquisition planner from National Instruments, Austin, Texas, was updated to include a number of new products from the company. The disk-based software helps users configure systems for PC/XT/AT/EISA and Micro Channel-based computers. Through its graphical interface, DAQ Designer asks the developer questions about system requirements, such as the type and number of analog and digital signals, the type and number of sensors and signals, and signal conditioning needs. The program analyzes the answers and recommends specific plug-in boards, conditioning products, cable assemblies, and software packages. After the user has selected the products, DAQ Designer creates a summary list that can be stored or printed. JN **CIRCLE 950**

DISK TEACHES CURES FOR DESIGN PROBLEMS

Designers working with high-speed ICs will find solutions to problems typically associated with such circuitry on an interactive application disk from Tektronix Inc., Beaverton, Ore. Topics covered include set-up and hold-time characterization, metastability, ground bounce, and modeling of interconnects. The disk visually explains the relevant concepts, presents solutions, shows instrument setups, and simulates instruments in a typical application. The program contains a number of "live" instrument displays that look exactly like what the user would see on an actual instrument. Users can set up measurements, change parameters, and view the results, all with accurate simulated waveform displays. JN **CIRCLE 951**

SHORT-FORM OPTO BOOK BURSTS WITH PRODUCTS

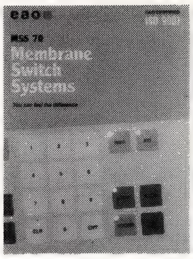


The 1994 edition of the short-form catalog from Siemens Optoelectronics Div., Cupertino, Calif., is four times larger than the last edition. The 88-pager includes details on intelligent display devices, military high-reliability displays, optocouplers, LED lamps, infrared and fiber-optic emitters, and custom products. The catalog also contains information on the company's product-quality programs. DM **CIRCLE 952**

GUIDE AIDS IN INTERNETWORKING

A free guide from Rad Network Devices, Costa Mesa, Calif., describes how bridges and guides are used to connect remote office LANs to a central network. The publication addresses ways to define the network type appropriate for various office situations. It includes a comprehensive review of both conventional and boundary routing approaches for connecting remote offices. In addition, information on total cost of ownership and potential network problems, such as fault tolerance issues, are presented to assist in choosing the best office network solution. The Guide to Branch Office Internetworking is available in pamphlet form or as a Windows-based version, with an interactive format, on diskette. CA **CIRCLE 953**

MEMBRANE SWITCHES IN CUSTOM CATALOG



A membrane-switching system designed to offer end users unparalleled flexibility is detailed in an eight-page, four-color catalog from EAO Switch Corp., Milford, Conn. The MSS 70 membrane-switch system catalog includes product photos, features, mounting dimensions, technical information, specifications, options, and components. A quotation-request form is included. DM **CIRCLE 954**

ISO 9000 GUIDE

A 220-page guide offers practical advice on ISO 9000 certification. The handbook, from the Society of Manufacturing Engineers, Dearborn, Mich., focuses on a six-phase plan for ISO 9000 implementation. It details the prevention of documentation overkill, internal quality audits, cost-of-quality benchmarks, and on-site audits. A four-tier hierarchical approach addresses issues of documentation for procedures, processes, and quality control. The handbook costs $51.00 for SME members, $55.00 for non-members. CA **CIRCLE 955**

POWER COMPONENTS DESCRIBED IN CATALOG

The full line of the latest component and configurable power solutions are detailed in a free 36-page, full-color catalog from Vicor Corp., Andover, Mass. The catalog is complete with photographs, descriptions, technical specifications, applications information, selection charts, and pricing and ordering information. DM **CIRCLE 956**

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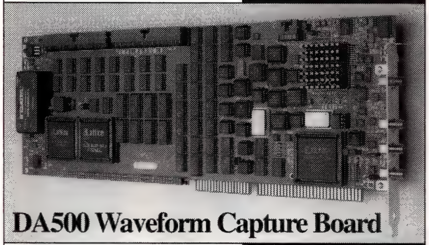

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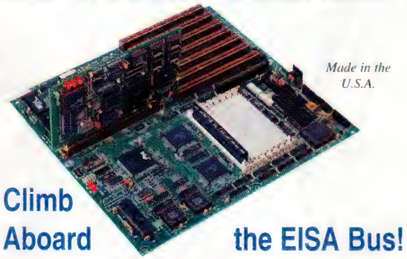

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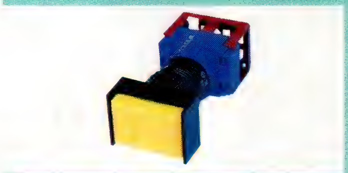

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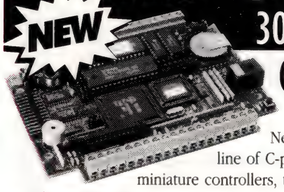

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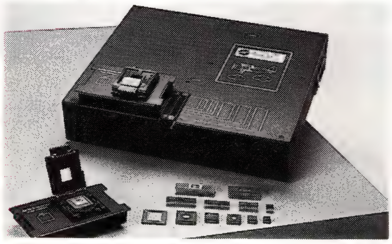

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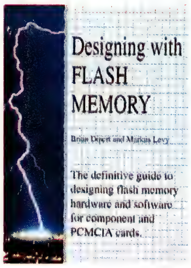
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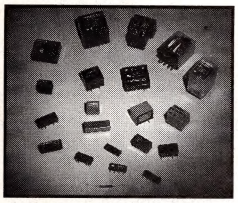

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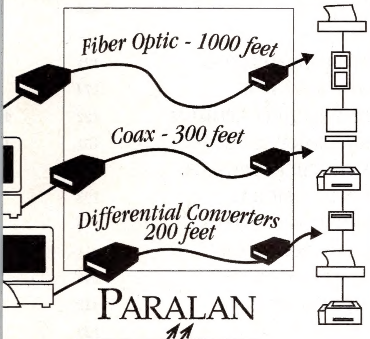

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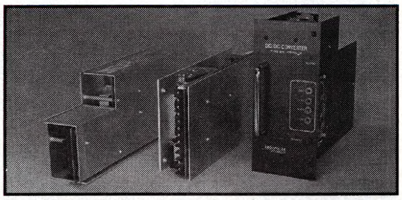

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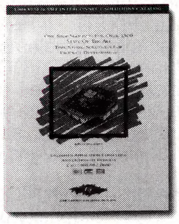

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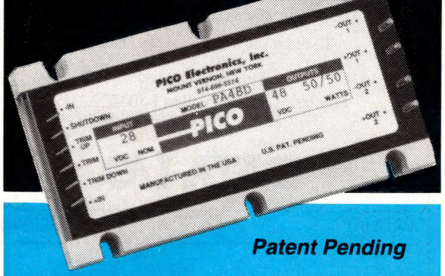

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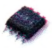

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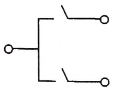

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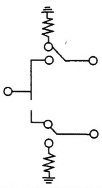

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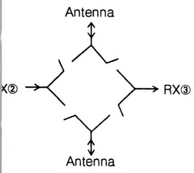

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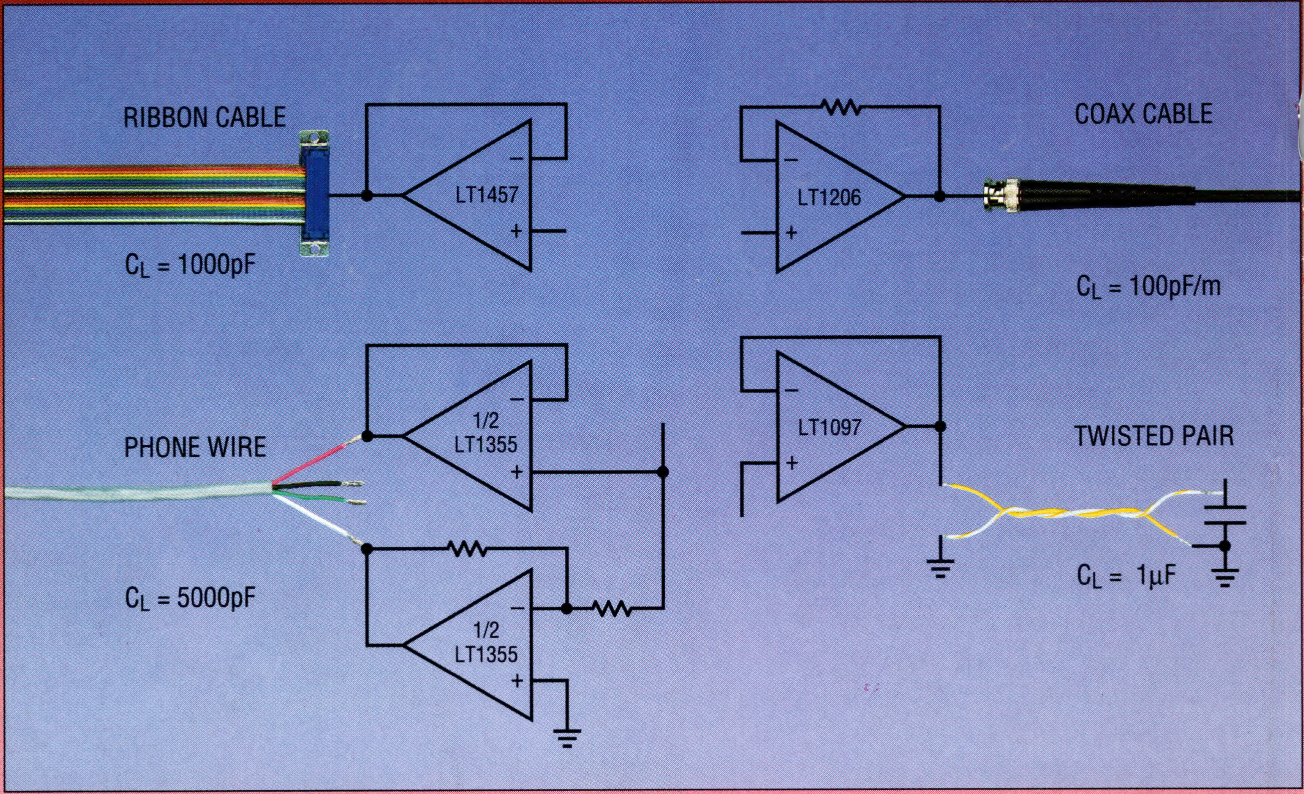

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Part #	Max V_{OS}	Max I_B	Min I_{OUT}	Bandwidth	Slew Rate
LT1097*	60µV	350pA	5.7mA	700kHz	0.2V/µs
LTC 1152	10µV	100pA	4mA	1MHz	1V/µs
LT1206	10mV	5µA	250mA	60MHz	900V/µs
LT1220	1.0mV	300nA	24mA	45MHz	250V/µs
LT1224*	2.0mV	8µA	24mA	45MHz	400V/µs
LT1354*	800µV	300nA	30mA	12MHz	400V/µs
LT1357*	600µV	500nA	30mA	25MHz	600V/µs
LT1360*	1.0mV	1µA	40mA	50MHz	800V/µs
LT1363*	1.5mV	2µA	70mA	75MHz	1000V/µs
LT1457	800µV	75pA	10mA	1.7MHz	4V/µs

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